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MORTALITY FROM HEART DISEASE IN ALBERTA: DISTRIBUTION TRENDS AND THE ENVIRONMENT

by

©

Gerda Bako

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled MORTALITY FROM HEART DISEASE IN ALBERTA: DISTRIBUTION TRENDS AND THE ENVIRONMENT, submitted by GERDA BAKO in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The geographical distribution of mortality from arteriosclerotic and degenerative heart disease (A.81) in the Province of Alberta was mapped and analyzed for fifteen Census Divisions and eight Municipalities for the five-year period 1964-68. The persistence over time of spatial trends of mortality in the province could be established by investigation of the preceding five-year period 1959-63. Percentage deviations of mortality rates from the Alberta average in the Census Divisions were mapped on choropleth maps and demographic base maps. Geographical "problem" areas of high mortality experiences were identified and geographical trends of increase in mortality were shown on isopleth maps.

By using the epidemiological approach and defining the environment as a potential stressor upon the human organism, especially of people at risk to die from heart disease, various environmental factors were examined. Influences of socio-economic factors in the environment could not be confirmed by statistical tests, but physical factors indicated powers of direct and indirect stressors present in the environment.

High mortalities from arteriosclerotic and degenerative heart disease in the southeastern half of Alberta were hypothesized to be associated, at least in part, with

distributions of high quantities of sodium ions in the water supply of these areas. High sodium levels in potable water supplies were thought to be promoted by water softening processes used in hard-water areas and by sodium rich solonetzic soils. High sodium contents in garden crops grown on solonetzic soils were also suspected, and together with high level sodium water supply were thought to donate sodium to man's diet and may, possibly, nullify the beneficial effect of a low-sodium diet prescribed for persons with heart ailments.

Since water, weather and climate, and soils are interdependent for many of their characteristics, they all qualify as suspect environmental stressors. Their relationship with high mortalities in "problem" areas of southeast Alberta was discussed, and recommendations for further research were proposed.

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Dr. H.V. Warren, Dept. of Geology, University of British Columbia, Vancouver, who encouraged this work. For the initial stimulus which led to my undertaking this task and for the enthusiasm for it, I want to express my deep felt gratitude to Dr. E.E. Bako.

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CHAPTER I

INTRODUCTION

The disturbingly large number of people disabled and dying from heart disease each year in many developed, industrialized countries of the world brought about large-scale investigation into those host- environment factors which could be suspected of being partly instrumental in the development of this almost "epidemic" disease (J.N. Morris, 1970). Environmental factors of physical, biological, and socio-economic design are being studied in many countries with the help of geographical distributional patterns of incidence of the disease. These patterns are of interest, as areal concentrations of mortality from heart disease frequently seem to assume significant proportions. Geographical variability of mortality rates, therefore, has stimulated the search for associated environmental factors. Various hypotheses were statistically tested and, in cooperation with the medical profession, evaluated clinically and in the laboratory, for the possible effects of environmental factors as causes of stress upon an organism.

High mortalities from heart disease shorten life expectancy, especially for male populations over

the world, and cause a loss of both life-years as well as productive working years before retirement. For humane reasons, as well as for economic ones, it is therefore important to discover all influences contributory to high mortalities from heart disease. One may, as a result, reduce some of the premature loss of human life and of the drain of resources imposed by the prevalence of this disease upon the total economy.

Many scientists, concerned about the increasing spread of heart disease, have rediscovered the importance of the environment as a source for pathogenic influences upon the organism (D.C. Graham, 1965). Epidemiologists and Medical Geographers (A.T.A. Learmonth, 1969-70) in cooperation, are well equipped to assess mortality patterns and their diversities, spatial trends and their possible relationship to environmental factors, and to come to conclusions which may contribute to a better understanding of the very complex, multicausal etiology of human heart disease (O. Kratochvil, 1971). The link between medical geography and geographical medicine is the epidemiological approach which is based upon the theory of an equilibrium among three classes of interacting factors (J.P. Fox et al.,1970):

1. the agent
2. the host and
3. the environment.

The class of "agent" factors, synonymous with primary

or true causes without which a specific disease cannot occur, may be, in character:

a) organic (e.g. viruses, bacteria, fungi etc.) and
b) inorganic (e.g. chemicals, metals etc.)

In this concept the "host" is man; host factors are: age, sex, heredity, race, adaptability, habits, exposure opportunity, defence mechanism stage, etc. "Environment" embraces all that is external to the agent and the human host in question, including fellow men. Environment factors are of three types:

a) physical (e.g. climate, geography, geology, soils, water etc.)
b) biological (e.g. plant and animal organisms)
c) socio-economic (e.g. income levels, urban-rural characteristics, housing, health facilities, etc.)

As long as the equilibrium among the three classes, agent, host and environment is preserved, health prevails. "Disease occurs when the balance is disturbed by forces with which one or more factors operate" (ibid., p.34). Important factors usually operate in concert (U.S. Public Health Service, 1968) and constitute by their interaction a so called "web of causation". Disease, as J.M. May (1961) defines it, is therefore a maladjustment situation, and its causation complex.

The link between medical geography and medicine requires the epidemiological approach for investigating spatial distributions of morbidity and mortality. The first stage in the approach is the mapping of the

distributions, the second is the correlation of occurrence with place and time as related to geographic circumstances. Here the environmental factors must be seen, evaluated, eliminated and identified as more or less influencing factors of stress. The third stage is that of collaboration and consultation with the medical expert both in laboratory and field for the purpose of further elimination of factors and the isolation and identification of causative agents.

Many studies undertaken during historical times take account of both man and his environment. Hippocrates, as early as the fourth century B.C., in his treatise "On Airs, Waters and Places" deals with the importance of the physical environment upon health (F. Henschen, 1966). Through the centuries, geographical thinking in medical research, or medical geography as it also was called, became modified by current cultural and philosophical trends, but always was an essential part of the endeavour to ease man's suffering and to discover the causes of it. One of the primary concerns of heart disease epidemiology, as in all other disease epidemiology, involves the answer to the question how morbidity and mortality are distributed. Spatial distribution research of mortalities is, therefore, basic to epidemiological studies of disease, and is being undertaken in an increasing number of countries. In Great Britain G.M. Howe (1963, 1970) produced for this purpose

the "National Atlas of Disease Mortality in the United Kingdom" mapping a group of important disease mortalities; and in 1972 he analyzed and discussed the mortality differences from heart disease occuring between and inside the cities of London and Glasgow.

In 1964 H.I. Sauer et al. investigated cardiovascular mortality patterns among middle-age males in Missouri, and attempted explanations for the diversity of death rate distributions in that state. H.I. Sauer and other researchers in 1966, again, studied mortality patterns of cardiovascular disease in Georgia and North Carolina, in order to discover possible factors responsible for distribution variations. They found strong indications for higher mortality occurrences to be associated with certain soil types; and recommended further epidemiological research concentrating on distributions associated with soils in other parts of the country. J.H. deHaas (1968) studied mortalities from heart disease in many countries of the world and found striking differences, but also similarities in distribution patterns among them. D. Hewitt in 1968 wrote about his studies of mortality from cardiovascular-renal disease in Ontario and elsewhere. He discribes mortality variations in the province and compares these with distribution patterns in other parts of Canada and the United States. N.D. McGlashan (1972) delivered a paper

to the IGU Symposium on Medical Geography in Guelph and focussed upon a distribution analysis of mortality from ischaemic heart disease in Tasmania. He found that mortality occurrences were persistently high in the southwest and southeast of that island State.
J.McD. Robertson and D.J. Hosking (1972) investigated regional patterns of mortalities from all causes and from specific causes in Saskatchewan over a ten-year period, and found definite upward trends, over time, of mortalities in certain parts of the province.

Medical geographic studies of mortality incidences, however, are not limited to descriptive analyses of distribution patterns or time trends in different areas. The importance of possible significant associations with factors of the environment in which diverse mortalities are shown, is expressed in many research papers. Weather and climatic factors in many parts of the world are analyzed for the influence they may have upon mortalities from heart disease. N.Ströder et al.(1951) emphasized the importance of weather disturbances upon heart disease patients, and classified weather conditions which they found to be possible, harmful stressors upon people with heart ailments. The climate - heart disease association was discussed also by W. Amelung in 1951, and recommendations were put forward for climatotherapy in the treatment of heart disease patients for preventive purposes. Also, L.A. Kapp and J.K. McGuire (1960) studied

climatic conditions in various parts of the United States and their influence upon cardiac patients. They made suggestions for the use of climatotherapy as preventive measures for persons with heart ailments. H.C. Teng and H.E. Heyer reported in 1955 certain general tendencies involving acute changes in weather which appear to bear a relationship to the onset of acute myocardial infarction. G.S. Berenson and G.E. Burch (1952) found evidence that persons with heart disease die readily from heat stroke, especially during heat waves in non-tropical areas of the world. S. Schnur (1956) states that in the southern states of the U.S.A., a greater mortality from acute myocardial infarctions was reported in the winter months than in the summer by the Houston Health Department for the years 1947-52. But N.P. DePasquale and G.E. Burch discovered in 1961, in New Orleans, that the highest death rates from heart disease occurred during the hottest and most humid month of August. They all emphasize the importance of climate in medical research.

Seasonal and climatic influences upon heart disease are also reported by G. Rose (1966) to be recognizable through studies done in England and Wales. He found that changes in temperature appear to be responsible for most short-term fluctuations in heart disease mortality. However, T.W. Anderson and W.H. LeRiche (1970) state that climatic influences upon heart disease mortalities are disputable, and suspect that seasonal

fluctuations of mortalities may be related to seasonal fluctuations of serious respiratory diseases which in turn are responsible for high mortalities from the disease. W. Czarniecki et al. (1969) found distinctive fluctuations of arterial blood pressure in patients during the passage of weather fronts, and indicate the practical value of their research for hypertension treatment of cardiac patients during these meteorological disturbances. R.E. Leslie (1963) describes the circulatory responses of man to his external environment in connection with weather and climate, and S. Licht (1964), B. deRudder (1952), and S.W. Tromp (1963) are well known for their works on Medical Climatology or Biometeorology in which they deal especially with weather and climate influences upon the physiological functions of the human organism.

Besides weather and climate, another climate-related environmental factor often associated with high heart disease mortalities in specific areas is the softness of the potable domestic water supply. Many studies similar to these on weather and climate in the environment were undertaken, and associations seem often to be significant. W.A. Sodeman and D. Meyer (1951) linked water softening processes practiced in Columbia, Missouri, in the treatment of hard water supplies, with a high level of sodium in the soft water supply. This they thought could adversely affect heart ailment patients

on low-salt diets (The Merck Manual 1972, p.1641). G.B. Elliott and E.A. Alexander (1961) discovered the presence of great quantities of sodium in untreated drinking water lifted from wells. Consumption of these waters by heart disease patients on low-salt diets lead to unsuspected and serious cardiac decompensations. The results of studies in Sweden by G. Biörck et al. (1965) confirm the many other studies linking hard drinking water to lower heart disease mortality; and H.A. Schroeder (1960 and 1961) found similar significant associations in the United States. M.D. Crawford and collaborators (1967-71) reported too that in general death rates from heart disease showed favourable tendencies in towns in England and Wales where the water supply had become harder, and unfavourable ones in towns where the water had become softer over time.

T.W. Anderson in cooperation with other researchers (1969) analyzed the soft and hard water associations with sudden deaths from ischaemic heart disease, and found higher proportions of deaths in soft water areas than in areas with a hard water supply. L.C. Neri et al.(1971), after a study of sudden deaths from heart disease in Ottawa, suggested that the values of water hardness in respect to mortality occurrences should also be related to trace elements in the potable water. F.W. Stitt et al.(1973) report on the clinical and biochemical indicators of cardiovascular disease among men

living in hard and soft water areas. The diastolic blood pressure, heart rate levels and plasma-cholesterol showed consistency within two contrasting groups in towns, and are believed to be important indicators for mortality occurrences between hard and soft water areas. Many other studies support the soft water - higher death rate hypotheses and various explanations were offered.

Contrary results also came to light, and R. Mulcahy (1964) in Ireland, R.D. Lindeman and J.R.Assenzo (1964) in Oklahoma, and J.H. Dingle et al.(1964) in the United States do not agree. According to their results significant association of soft water supply with the increase of mortality occurrence from heart disease was not conclusive, mainly because they felt that qualities other than total water hardness must be taken into account.

The research into physical environmental factors and heart disease mortality is frequently accompanied by assessments of socio-economic factors in the same environment. The incidence of myocardial infarctions was studied by F. Dreyfuss (1953) in Israel with an emphasis on the ethnic backgrounds of the people concerned. Association between morbidity and mortality incidence and ethnology were found to be significant. P.W.Enterline et al. (1960) compared heart disease mortalities in metropolitan with non-metropolitan areas in the United States, and found that death experiences were usually,

but not always, higher in metropolitan than in non-metropolitan counties. They also showed that differences existed among metropolitan areas with higher rates.

A comprehensive study by H.I. Sauer (1962) previously mentioned, showed also that associations of death rate distributions with specific ethnic groups existed. In the Middle Atlantic States of the U.S. highest deaths from cardiovascular disease occurred among people of Irish origin while Swedes and Germans rank lowest. In 1966 H.I. Sauer researched economic sub-regions in Georgia and North-Carolina and found substantial differences between them for heart disease mortality. J. Robertson and D.J. Hosking (1972), G.W. Shannon and J.L. Skinner (1972) and J.L. Girt (1971) discuss in their papers possible associations between the availability of health service facilities and disease ecology. Distance and travel time to medical care, they feel, influence disease and mortality patterns.

A great amount of research into the geographical distribution of heart disease mortalities and the association of diversities among them with the physical and socio-economic environment in which they occur, has been undertaken in many countries of the world. Very few studies of this sort were performed in Canada; and, to the writer's knowledge, no serious assessment of geographical distribution patterns of arteriosclerotic and degenerative heart disease in the Province of Alberta

has so far been made. Because heart diseases in this province rank in first place for all causes of deaths (Government of Alberta, 1964-70), and because they are of great concern to the medical profession and to the public, medical geographical research in this area is believed to be of great value and, long overdue.

A discovery of distribution patterns, mortality and morbidity intensities in certain areas, persistency of identified patterns over time, and possible associations of these patterns with prevailing environmental situations, can lead to the better understanding of heart disease etiology in Alberta. Studies of this nature promise to provide clues for utilization in future research by medical practitioners and Health Service Officers in their search for preventive measures designed to ease the threat upon the population at risk who are most liable to succumb prematurely to heart disease.

The scope of this thesis will encompass the distribution by Census Divisions and Municipalities of the specific-cause mortality: arteriosclerotic and degenerative heart disease, in the Province of Alberta for males and females. Investigations of environmental factors which may be associated with these mortality distributions will be made. The methods applied in the research will be described, and the results obtained

will be discussed. The work is organized into two main sections. The first one deals with the geographical distributions of arteriosclerotic and degenerative heart disease mortality in the province, and the second one with the association of mortality occurrences and their spatial distributions with the occurrences and distributions of selected factors of a physical and socio-economic character in the environment of Alberta. Finally, conclusions are drawn from the results obtained in both sections; and recommendations for further research are proposed.

It is hoped, that medical geographical research, little known in Alberta as a field of the applied sciences, may become a tool of frequent use by geographers and medical researchers alike; and that its value as an applied science for the benefit of public health and a better quality of life will be recognized.

> "The study of medical-geographic differences within our country is a potentially rich source of knowledge about the basis of our own health, particularly if it is attacked in an imaginative way in co-operation with sociologists, geneticists, nutritionists, physiologists and epidemiologists. ..... The opportunities for the study of geographic medicine in this country are waiting to be exploited." (Can. Med. Ass. Journal, Editorial, 1965)

CHAPTER II

METHODOLOGY FOR ANALYSIS OF THE SPATIAL DISTRIBUTION OF ARTERIOSCLEROTIC AND DEGENERATIVE HEART DISEASE MORTALITY IN ALBERTA

Mortality experiences from combined categories of heart disease in the Province of Alberta in 1966 accounted for 31 per cent of the total deaths. 27 per cent of all deaths were caused by arteriosclerotic and degenerative heart disease, further referred to as A.81 (World Health Statistics Annual, 1966). During the period 1964-68, an average of 2,666 persons died annually from heart disease A.81, 1,819 males and 847 females. These constitute a high enough percentage of deaths to deserve investigation.

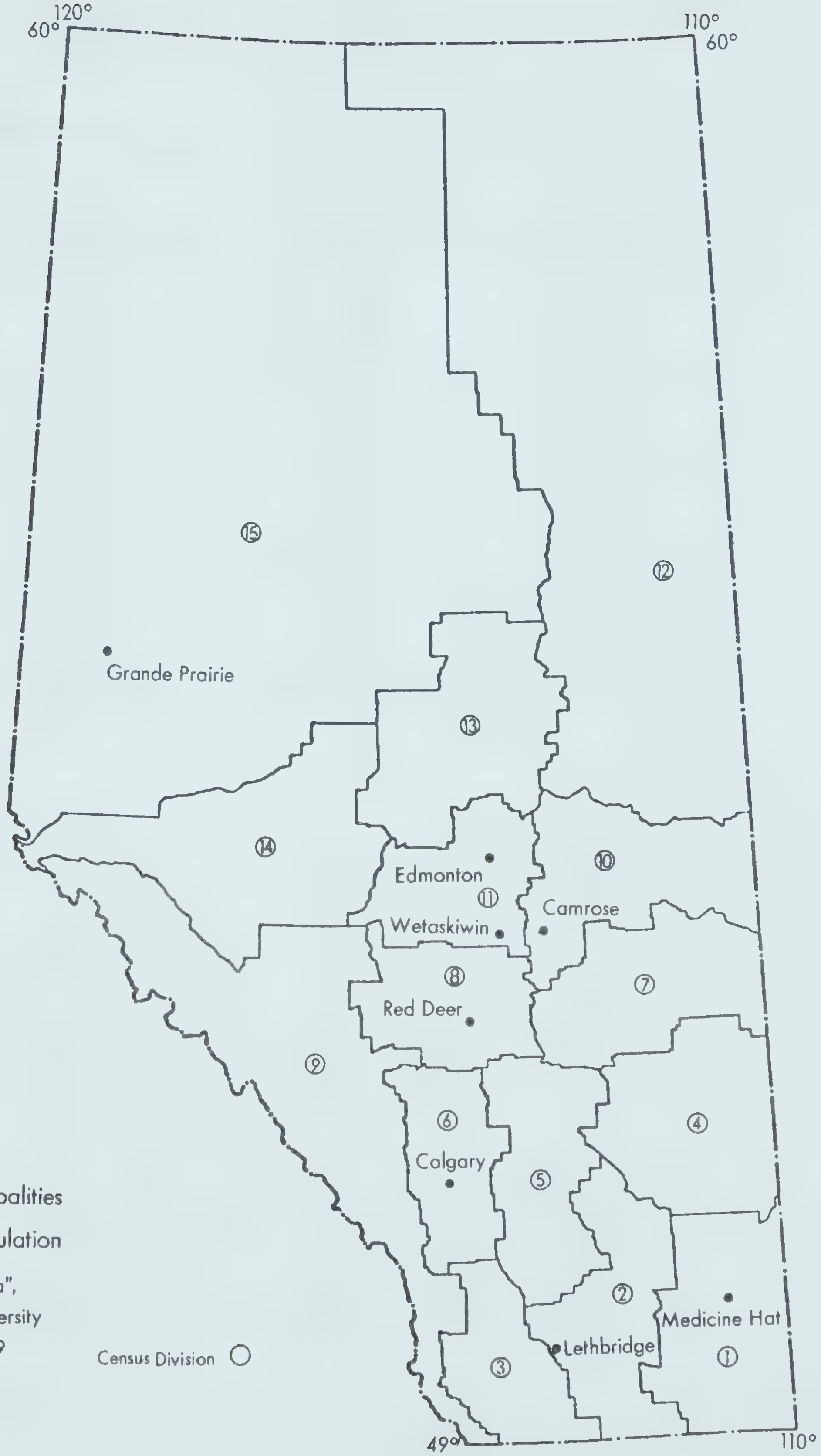
This preliminary survey indicates the significance of loss of life in the province due to disease A.81. Mortality rates and their percentage deviations from the Alberta average were chosen as indicators for the research on two scales: for Census Divisions and for Municipalities over 5,000 population. A possible trend of distribution patterns persisting through time was checked by a study of data for two consecutive five-year time periods.

The Province of Alberta, bound in the north by the Northwest Territories at the 60th parallel,

in the south by the International Boundary and the State of Montana at the 49th parallel, in the west by British Columbia, and in the east by the Province of Saskatchewan, is divided into fifteen Census Divisions for enumeration purposes (figure 1). The population density varies considerably between Census Divisions located in the northern and in the southern half of the province. This is a result of the diversities in population numbers and the areal extent of the Census Divisions.

Municipalities in Alberta with over 5,000 population are scattered widely and are small in number. Only one municipality is located in the northern half and the other seven in the southern half of Alberta. However, the distribution is scattered enough to incorporate a number of very different physical and socio-economic environments in the province.

Mortality data for disease A.81 for males and females over the five-year period 1964-68 for the fifteen Census Divisions were averaged (table 1). Standardized mortality rates were calculated for each Census Division on the basis of the age structure of the population in the 1966 census year, using five-year age-groups, to enable comparisons of populations with youthful and with aged characteristics. The indirect method of standardization (J.P. Fox et al.,1970 and A.B. Hill, 1961)



ALBERTA

Census Divisions and
Location of 8 Municipalities
with over 5,000 population

source: "Atlas of Alberta",
Govt. and University
of Alberta, 1969

Figure: 1

Table 1: Number of population in Alberta by Census Divisions, 1966, and deaths from A.81 during the period 1964-68

Number of population

Census Division	Males	Females	Total
1	19,523	19,335	38,858
2	42,187	40,532	82,719
3	15,196	14,396	29,592
4	7,648	6,576	14,224
5	18,793	17,194	35,987
6	184,347	184,793	369,140
7	21,219	19,614	40,833
8	43,248	40,664	83,912
9	9,582	8,613	18,195
10	36,618	33,593	70,211
11	239.697	236,356	476,053
12	26,867	23,768	50,635
13	23,429	20,713	44,142
14	10,978	9,380	20,358
15	46,913	41,431	88,344
	746,245	716,958	1,463,203

Number of deaths

Census Division	Males	Females	Total
1	363 (72.6)	203 (40.6)	566
2	593 (118.6)	267 (53.4)	860
3	221 (44.2)	104 (20.8)	325
4	143 (28.6)	52 (10.4)	195
5	327 (65.4)	135 (27.0)	462
6	1,891 (378.2)	1,031 (206.2)	2,922
7	321 (64.2)	168 (33.6)	489
8	546 (109.2)	224 (44.8)	770
9	125 (25.0)	43 (8.6)	168
10	697 (139.4)	331 (66.2)	1,028
11	2,701 (540.2)	1,259 (251.8)	3,960
12	259 (51.8)	101 (20.2)	360
13	347 (69.4)	125 (25.0)	472
14	102 (20.4)	34 (6.8)	136
15	459 (91.8)	160 (32.0)	619
	9,095	4,237	13,332

() annual average of deaths

was applied:

$$D.R._{C.D.} = \frac{o.d.}{e.d.} (D.R._{st}) \; . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (1)$$

where $D.R._{C.D.}$ is the standardized death rate by sex and age in the Census Division,

o.d. is the averaged annual number of observed deaths in the Census Division,

e.d. is the annual expected number of deaths in the Census Division, and

$D.R._{st}$ is the crude death rate for the whole province.

The calculated mortality rates for the fifteen Census Divisions were then statistically tested; and a Census Division rate is considered to be statistically significant at the five per cent level of confidence from the provincial rate when the difference between them is more than twice the standard error of the Census Division (G.M. Howe, 1963).

For each Census Division the percentage deviation from the Alberta average was calculated and mapped for males and females separately on chorographic maps. The percentage deviation intervals, although they differ both between the sexes and, in the "above" and "below" categories, were not arbitrarily chosen, but were indicated by the calculated significance level of the two standard errors (table 2).

To avoid any incorrect visual impression of regional intensities of mortality occurrences, death rate deviations for each sex were also mapped on

Table 2: Death rates (A.81) and percentage deviations from the Alberta average (1964-68) by Census Divisions, and number of populations at risk for males and females (1966)

Males

Census Division	Death rate p.100,000		%-deviation	Population at risk(45+ years)
1	304.11		+ 26.18	5,662
4	294.89		+ 22.36	2,147
5	272.72	**	+ 13.16	5,615
11	264.15		+ 9.61	52,377
10	260.73		+ 8.19	11,895
3	246.19		+ 2.15	4,160
2	244.39	*	+ 1.41	11,433
9	233.40		- 3.15	2,780
8	231.83		- 3.81	11,517
7	230.10		- 4.52	6,248
13	230.10		- 4.52	7,121
15	226.60		- 5.98	10,085
6	218.85		- 9.19	41,722
14	209.98	**	- 12.87	2,448
12	204.21		- 15.27	5,925
				181,135

Females

Census Division	Death rate p.100,000		%-deviation	Population at risk (55+ years)
1	161.23		+ 34.36	3,308
10	137.71	**	+ 14.75	6,216
4	136.31		+ 13.59	1,004
5	133.53		+ 11.28	2,780
7	127.62		+ 6.35	3,153
11	121.28		+ 1.07	28,921
14	120.59	*	+ 0.49	934
2	117.94		- 1.72	6,670
15	117.51		- 2.08	4,331
13	117.28		- 2.27	3,297
6	107.78		- 10.18	24,778
12	107.12		- 10.72	2,657
3	104.68	**	- 12.77	2,453
8	102.25		- 14.78	5,905
9	100.09		- 16.59	1,402
				97,809

*Alberta average(rounded): Males 241 p.100,000
Females 120 p.100,000

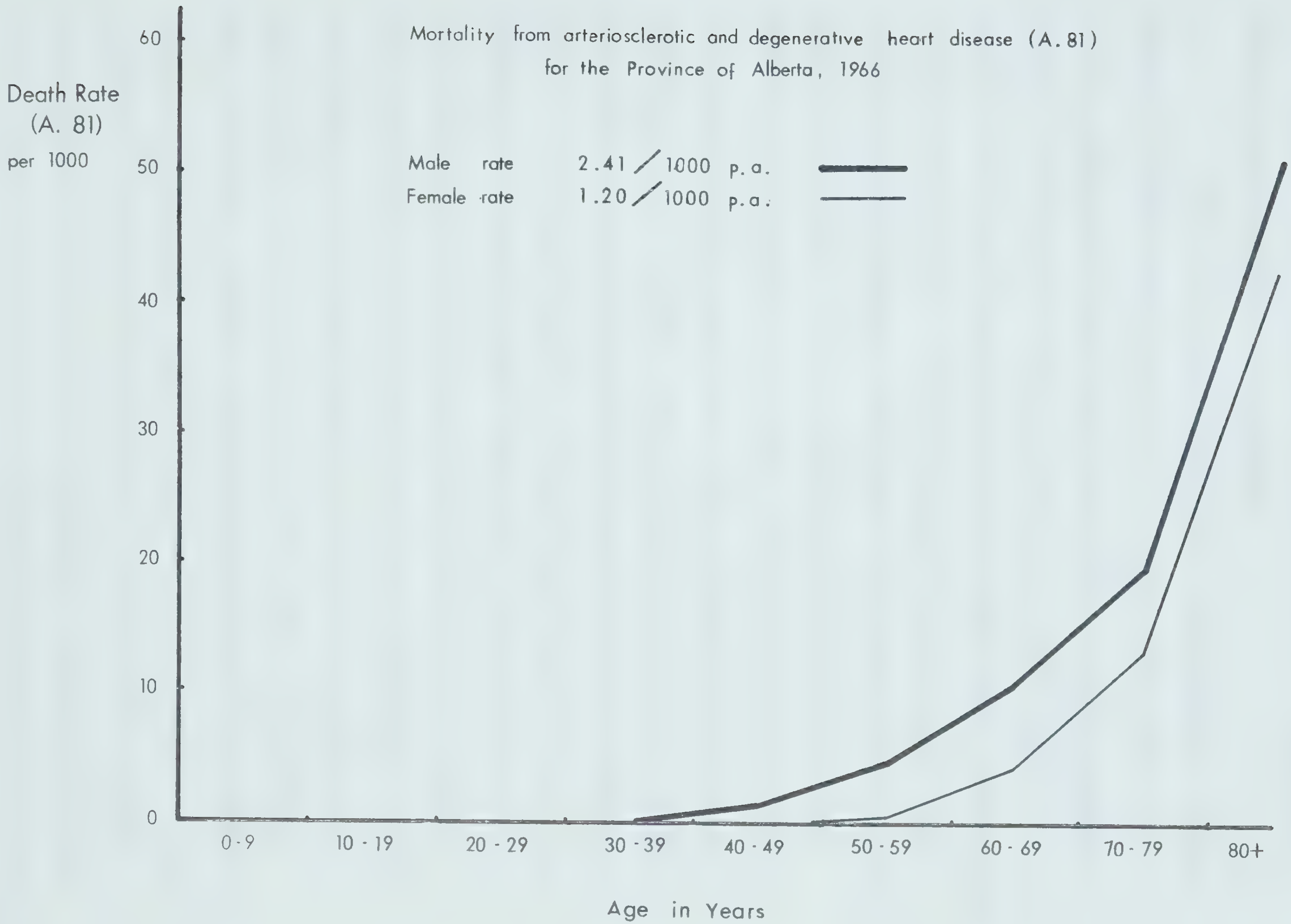
**Statistically significant at the 5 per cent level

demographic base maps which present the population at risk proportional to the areas of squares. It was calculated that the population at risk involves the ages 45 years and over for males, and for females the ages 55 years and over. Since there is no universal value set as to the age of the population at risk to die from heart disease A.81, this age was derived from figure 2 at the age level where the first angle of increase appears on the curves. This method was used in a similar study by N.D. McGlashan in Tasmania (N.D. McGlashan, 1972). The demographic base map is a necessary addition since the populations at risk differ considerably in size between Census Divisions.

To above mentioned mapping techniques which showed, as will be discussed later, a directional spatial variation in percentage deviations of mortality rates for A.81, was added an isopleth map for each sex separately. Its purpose is to clarify the directional variation visually, and to provide a possible base for later correlations of mortality rates with environmental factors.

The requirements for the construction of an isopleth map in this case were first: to establish control points representing the center of gravity of the population in each of the fifteen Census Divisions; secondly an isopleth interval had to be selected which would

Figure 2


Mortality from arteriosclerotic and degenerative heart disease (A. 81)
for the Province of Alberta, 1966
Male rate 2.41 / 1000 p. a.
Female rate 1.20 / 1000 p. a.
Death Rate
(A. 81)
per 1000
60
50
40
30
20
10
0
0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 - 59
60 - 69
70 - 79
80+
Age in Years

clearly indicate significant deviations of mortality rates from the Alberta average.

The often used method of locating the control points at the areal center of an administration unit (A.T.A. Learmonth and M.N. Pal, 1959; and J.R. MacKay, 1951), assuming uniform population distribution in that unit, could not be applied, since populations, especially in the northern and western Census Divisions are not evenly spread through the Census Divisions. The control points, therefore, were calculated as follows: Areal centers of subdivisions such as Improvement Districts (assigned by the government for physical and economic development), Counties, Municipal Districts and Indian Reservations were mapped and marked with the population number they represented. Cities, towns and villages in descending order of size were also located on the map and marked with their population number. The points were accumulated on the map until approximately ninety per cent of the population in a Census Division was represented. From these points the center of gravity was calculated by their proportional weight and distance from one other. Each pair of points was replaced by one fulcrum point which in turn was coupled with another fulcrum point and a new fulcrum point calculated. Thus, by successive elimination of points the center of gravity was found in the last remaining fulcrum point. This method

for selection of the center of gravity for populations in the Census Divisions seemed to be preferable to areal mid-point location, and to be sufficiently accurate for the small-scale maps used here.

The isopleth interval was selected as follows: Categories from 1 to 5 were assigned to the percentage deviation ranges, number 3 representing deviations close to the Alberta average, 1 and 2 the significantly below, and 4 and 5 the significantly above deviation ranges from the Alberta average. The isopleth interval, then, of 1 represents the listed percentage deviation range boundaries from the Alberta average (table 3) and its function is to separate subjectively the units of percentage deviation ranges rather than symbolize actual quantitative measurements of deviation increases or decreases about the Alberta mean.

The geographical distribution of mortalities A.81 was further investigated by consideration of municipalities with over 5,000 population. This scale of enumeration units was decided upon for the following reasons: First, resulting distribution patterns with directional increase trends of mortalities could prove to be supporting the larger unit - Census Division- distribution, and secondly, the data on municipalities could be useful for correlations with environmental data which are available only for municipalities. The locations

Table 3: Categories for the percentage deviation ranges of mortality rates (A.81) from the Alberta average for males and females used for isopleth maps, Census Divisions 1964-68

Males

%-deviation	category	Census Division
above average		
18 - 27 **	5	1, 4,
8 - 17 **	4	5, 10, 11,
0 - 7		
below average	3 *	2, 3, 7, 8, 9, 13, 15,
0 - 6		
7 - 11 **	2	6,
12 - 16 **	1	12, 14,

Females

%-deviation	category	Census Division
above average		
24 - 36 **	5	1,
11 - 23 **	4	4, 5, 10,
0 - 10		
below average	3 *	2, 7, 11, 13, 14, 15,
0 - 9		
10 - 13 **	2	3, 6, 12,
14 - 17 **	1	8, 9,

**statistically significant at the 5 per cent level

* average

of the municipalities are shown on figure 1.

Mortality data for heart disease A.81 in the eight Alberta municipalities of more than 5,000 population covering the five-year period 1964-68 were averaged (table 4). Standardized mortality rates (indirect method of standardization as above) were calculated for each municipality on the basis of the age structure of the total population of Alberta in the 1966 census year in order to eliminate possible diversions of rates due to old or young populations.

The death rates were next analyzed for their deviations from the mean of all municipalities (at the five per cent level of confidence) for each sex separately, and the percentage deviation of each municipality was calculated (table 5). The Alberta standard rate was not used here since the deviation among the municipalities was of primary interest for a possibly existing spatial trend. Following the same procedure as for Census Divisions, the percentage deviations were categorized (table 6) into five groups ranging from 1 to 5, that is, from the lowest to the highest deviation around the mean, 3, of the municipalities. The category values were mapped for each sex by using isopleths. This method provides an easier visual assessment of significant spatial variations of mortality experiences between municipalities, and directional trends of increases or decreases.

Table 4: Number of population in eight Alberta municipalities over 5,000 in 1966, and deaths from A.81 during the period 1964-68

Number of population

Municipality	Males	Females	Total
Edmonton(incl.St.Albert)	192,246	194,415	386,661
Calgary	164,151	166,424	330,575
Lethbridge	18,318	18,868	37,186
Red Deer	12,956	13,215	26,171
Medicine Hat	12,439	13,135	25,574
Grande Prairie	5,783	5,634	11,417
Camrose	4,093	4,269	8,362
Wetaskiwin	2,970	3,038	6,008
	412,956	418,998	831,954

Number of deaths

Municipality	Males	Females	Total
Edmonton(incl.St.Albert)	2,176 (435.2)	1,072 (214.4)	3,248
Calgary	1,576 (315.2)	884 (176.8)	2,460
Lethbridge	311 (62.2)	164 (32.8)	475
Red Deer	114 (22.8)	64 (12.8)	178
Medicine Hat	294 (58.8)	177 (35.4)	471
Grande Prairie	65 (13.0)	30 (6.0)	95
Camrose	157 (31.4)	90 (18.0)	247
Wetaskiwin	72 (14.4)	32 (6.4)	104
	4,765	2,513	7,278

() annual average of deaths

Table 5: Death rates (A.81) and percentage deviations from the average in eight municipalities of over 5,000 population, 1964-68, for males and females

Males

Municipality	Death rate p.100,000		%-deviation
Camrose	349.43	**	+ 25.24
Wetaskiwin	333.24	**	+ 19.44
Medicine Hat	332.18	**	+ 19.06
	*		
Edmonton(incl.St.Albert)	272.54		- 2.31
Lethbridge	252.17		- 9.62
Grande Prairie	247.78		- 11.19
Red Deer	227.38	**	- 18.50
Calgary	215.21	**	- 22.86

Females

Municipality	Death rate p.100,000		%-deviation
Medicine Hat	166.67	**	+ 28.21
Camrose	165.11	**	+ 27.01
	*		
Lethbridge	125.12		- 3.76
Edmonton(incl.St.Albert)	124.11		- 4.53
Wetaskiwin	122.54		- 5.74
Grande Prairie	121.47		- 6.56
Red Deer	106.18	**	- 18.32
Calgary	104.91	**	- 19.30

*average(rounded): Males 279 p.100,000
Females 130 p.100,000

**statistically significant at the 5 per cent level

Table 6: Categories for the percentage deviation ranges of mortality rates (A.81) from the average in eight Alberta municipalities, and list of municipalities with categories for males and females, 1964-68 used for isopleth maps

Males

%-deviation	category
above average	
22 - 26 **	5
17 - 21 **	4
0 - 16	3 *
below average	
0 - 15	3 *
16 - 20 **	2
21 - 25 **	1

Females

%-deviation	category
above average	
27 - 32 **	5
21 - 26 **	4
0 - 20	3 *
below average	
0 - 10	3 *
11 - 16 **	2
17 - 22 **	1

Municipality	category, Males	category, Females
Camrose	5	5
Wetaskiwin	4	3
Medicine Hat	4	5
Edmonton(incl.St.Albert)	3	3
Lethbridge	3	3
Grande Prairie	3	3
Red Deer	2	1
Calgary	1	1

** statistically significant at the 5 per cent level
* average

The results of the above investigations showed clearly spatial distribution patterns and directional trends for highest mortalities from heart disease A.81. It seemed to be valuable, therefore, to find out, if, and to what extent these patterns and trends did persist over time. If the assumption of similarities over time proves to be correct, one may pursue with greater confidence correlations between "problem" areas of high mortality and environmental factors which may be instrumental in, or contributory to deaths from A.81.

The method used for calculating the mortality rates for the fifteen Census Divisions was identical to the above mentioned, except that the data were collected for the preceding five-year period 1959-63. The standardized mortality rates (indirect method of standardization) were calculated on the basis of the age structure of the population of Alberta in the census year 1961 for both sexes (table 7 and 8).

For each Census Division the percentage deviation from the Alberta average was calculated (table 8) for each sex and ordered into five categories, from 1 to 5, category 3 indicating non-significant deviations from the average. These category values were mapped at the Census Division control points, i.e. at the centers of gravity for the respective populations, and isopleths were drawn through these points. The isopleth interval, as mentioned above,

Table 7: Number of population in Alberta by Census Divisions, 1961, and deaths from A.81 during the period 1959-63

Number of population

Census Division	Males	Females	Total
1	19,835	19,305	39,140
2	43,101	40,205	83,306
3	16,009	14,958	30,967
4	8,168	6,852	15,020
5	20,266	17,849	38,115
6	161,032	156,957	317,989
7	21,510	19,327	40,837
8	40,040	36,493	76,533
9	11,080	9,194	20,274
10	36,986	33,191	70,177
11	209,518	201,161	410,679
12	25,387	21,923	47,310
13	24,575	20,856	45,431
14	10,683	8,599	19,282
15	41,193	35,691	76,884
	689,383	642,561	1,331,944

Number of deaths

Census Division	Males	Females	Total
1	291 (58.2)	159 (31.8)	450
2	542 (108.4)	240 (48.0)	782
3	176 (35.2)	97 (19.4)	273
4	151 (30.2)	49 (9.8)	200
5	324 (64.8)	99 (19.8)	423
6	1,537 (307.4)	855 (171.0)	2,392
7	330 (66.0)	133 (26.6)	463
8	525 (105.0)	192 (38.4)	717
9	145 (29.0)	51 (10.2)	196
10	625 (125.0)	316 (63.2)	941
11	2,447 (489.4)	1,026 (205.2)	3,473
12	275 (55.0)	95 (19.0)	370
13	367 (73.4)	106 (21.2)	473
14	122 (24.4)	27 (5.4)	149
15	405 (81.0)	103 (20.6)	508
	8,262	3,548	11,810

() annual average of deaths

Table 8: Death rates (A.81) and percentage deviation from the Alberta average (1959-63) by Census Divisions

Males

Census Division	Death rate p.100,000		%-deviation
4	279.71		+ 17.03
11	275.60		+ 15.31
5	271.95	**	+ 13.79
1	258.50		+ 8.16
14	256.28		+ 7.23
9	248.21		+ 3.85
10	246.08		+ 2.96
13	244.00		+ 2.09
8	240.65	*	+ 0.69
7	234.85		- 1.74
2	234.40		- 1.92
12	229.66		- 3.91
15	218.99		- 8.37
3	198.69	**	- 16.87
6	197.10		- 17.53

Females

Census Division	Death rate p.100,000		%-deviation
10	136.76		+ 34.08
4	133.98		+ 31.35
1	129.12		+ 26.59
2	117.42	**	+ 15.12
11	117.09		+ 14.79
9	115.41		+ 13.15
14	110.59		+ 8.42
7	108.05		+ 5.93
12	107.14		+ 5.04
5	106.99		+ 4.89
3	105.95	*	+ 3.87
13	101.07		- 0.91
6	100.51		- 1.46
8	95.95		- 5.93
15	85.06	**	- 16.60

* Alberta average(rounded): Males 239 p.100,000
Females 102 p.100,000

**statistically significant at the 5 per cent level

must not be interpreted as homogeneous in quantitative value since its function is only to provide for a qualitative measure of directional increase or decrease in mortality from heart disease A.81 during the five-year period 1959-63. The purpose of the isopleth maps, therefore, is the same as for the 1964-68 period and allows a visual comparison of the two periods in respect of the persistence of the directional pattern over time.

The shortcomings inherent in all census data and standardization methods must be realized and taken into account. However, it is assumed that the data can provide a reasonable amount of accuracy when comparisons between smaller areas are undertaken inside a larger area where medical standards and methods to collect census statistics are homogeneous (H.I. Sauer, 1959 and 1962).

CHAPTER III

RESULTS OF ANALYSIS, 1959-63 AND 1964-68

The total number of deaths from A.81 in the province for the study period 1964-68 was 13,332. Males experienced over twice as many deaths as females, 9,095 compared to 4,237 (table 1). The crude death rate per 100,000 for the male population in the province for 1966 was 241.07 and for females 119.53 (rounded for mapping purposes to 241 and 120 respectively). The age-adjusted mortality rates for both sexes in the fifteen Census Divisions are shown on table 2 in descending order.

The range of death rates for males is from 204.21 to 304.11, and for females from 100.09 to 161.23. Five Census Divisions had statistically significant death rates above the provincial average for males, and three Census Divisions had significant rates below. For females, four Census Divisions had rates above, and five Census Divisions had rates below the provincial average at the same significance level. The male population at risk in all of Alberta numbered 181,135 in 1966, the female population 97,809.

The percentage deviations from the Alberta average for males (table 2) range from 26.18 above to 15.27 below, and for females from 34.36 above to 16.59

below the Alberta average for the five-year study period. This indicates a wider deviation range for females than for males.

The geographical distribution of mortality rates for males expressed as percentage deviations (figure 3) shows significantly high mortalities and deviations of 18-27 per cent above the Alberta average in Census Divisions 1 and 4, located in the southeast corner of the province. Significantly low mortalities and deviations of 12-16 per cent below the provincial average were found in Census Divisions 12 and 14 in, approximately, the northern half of the province. Significant deviations of 8-17 per cent above were observed in the east-central Census Divisions 11 and 10, and south-central Census Division 5; while deviations of 7-11 per cent below occurred in Census Divisions 6 in the southwest of the province. The remaining deviations of 0-7 per cent above and 0-6 per cent below the Alberta average in Census Divisions 2, 3, 7, 8, 9, 13 and 15 are not statistically significant since they lie too close to the Alberta average.

The male population at risk (45 years and over) in Alberta differed in number in the Census Divisions (figure 4). The greatest number of males was located in the two metropolitan Census Divisions 6 and 11, including the cities of Calgary and Edmonton with over 40,000 males each. In the remaining thirteen Census Divisions this

Death Rate (A. 81)

Percentage Deviation from

Alberta average: 241 per 100,000

for

Males

1964 · 1968

numbers represent Census Divisions

above

18-27%*

8-17%*

0-7%

below

0-6%

7-11%*

12-16%*

*Statistically significant at the 5% level

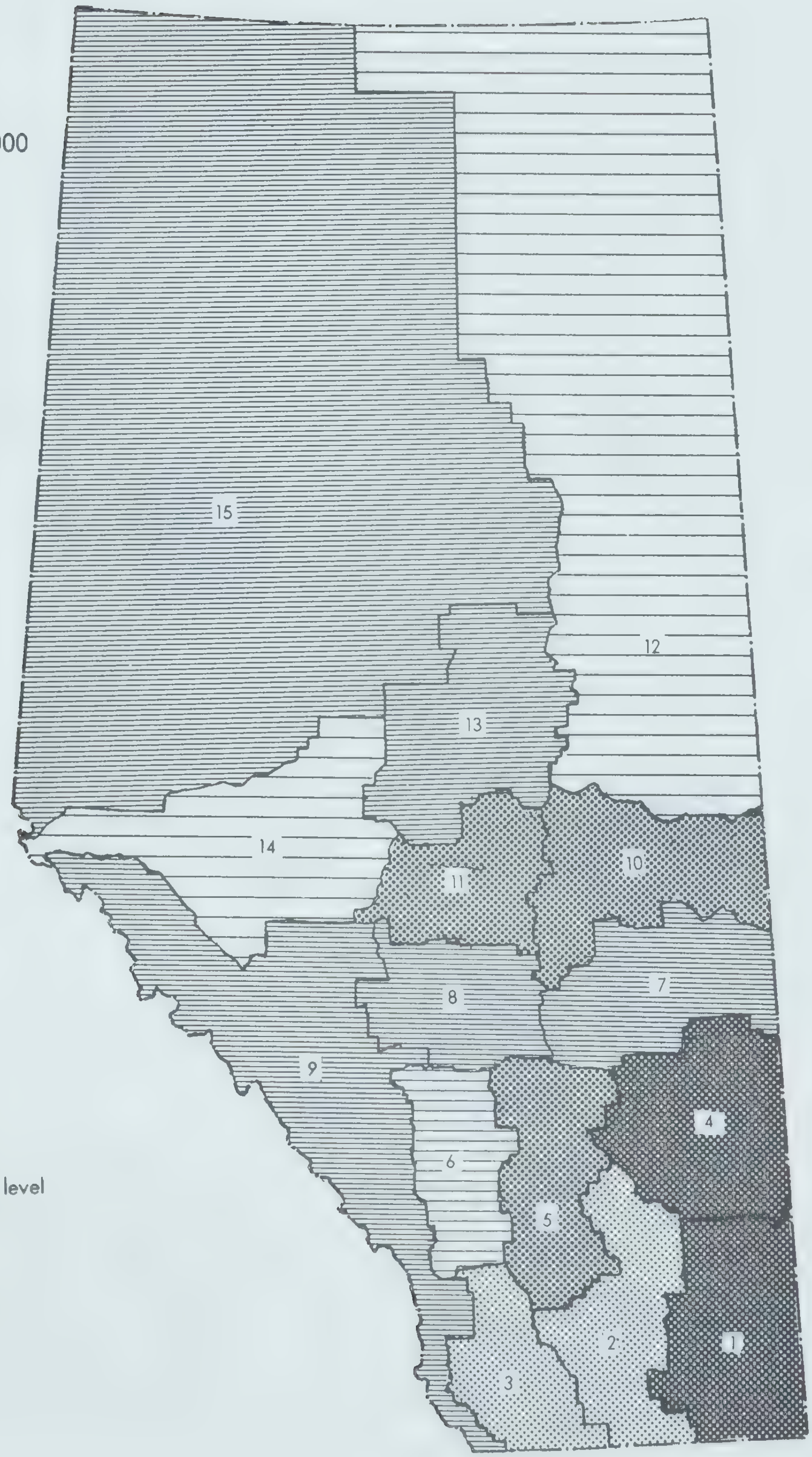


Figure 3

Population at Risk

in 1966

and Percentage Deviation of

Death Rates (A. 81) from the

Alberta average for

Males (45+ years)

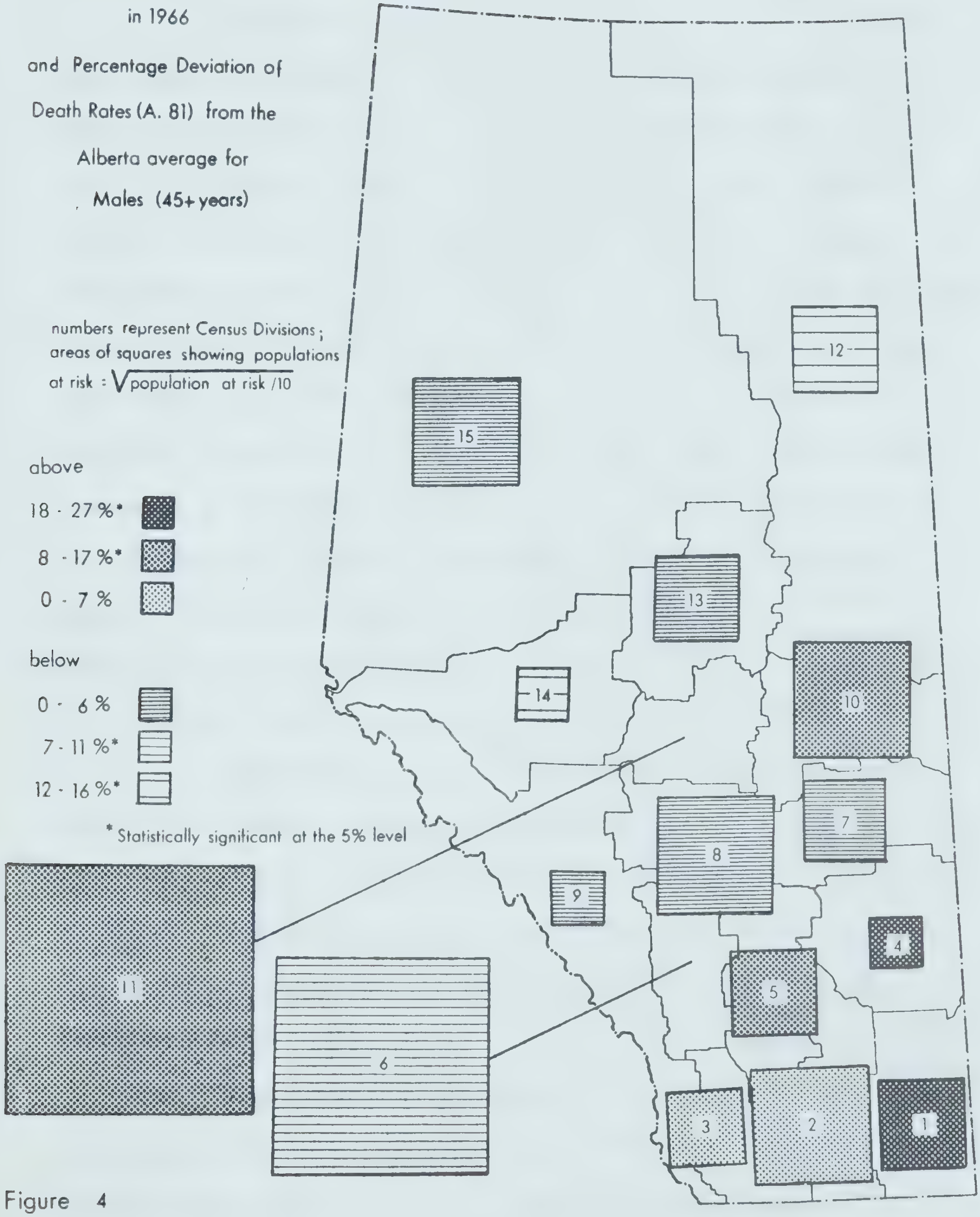


Figure 4

population was considerably smaller, ranging from 2,000 to 12,000 persons (table 2).

High mortalities and deviations of 24-36 per cent above the Alberta average for females (figure 5) were experienced, again, in the Census Division 1 located in the southeast corner of the province. Significant deviations of 14-17 per cent below occurred in Census Divisions 8 and 9 in the southwestern part of the province. Deviations of 11-23 per cent above were found in Census Divisions 4, 5 and 10 in approximately the southeast of Alberta. Deviations of 10-13 per cent below the average occurred in Census Divisions 3, 6 and 12 of which the first two are located in southwestern Alberta and the third in the northeast. Deviations from 10 per cent above to 9 per cent below in Census Divisions 2, 7, 11, 13, 14 and 15 are not statistically significant.

The female population at risk (55 years and over) in Alberta (figure 6) was greatest in number in the metropolitan Census Divisions 6 and 11 with over 24,000 persons each. In the remaining Census Divisions the female population number ranged from about 1,000 to some 6,000 (table 2).

The spatial distribution of mortality experiences for the five-year study period by sex is summarized on the isopleth maps (figure 7 and 8). The average percentage deviations are marked by isopleth

Death Rate (A. 81)

Percentage Deviation from

Alberta average: 120 per 100 000

for

Females

1964 - 1968

numbers represent Census Divisions

above

24-36%*

11-23%*

0-10%

below

0-9%

10-13%*

14-17%*

* Statistically significant at the 5% level

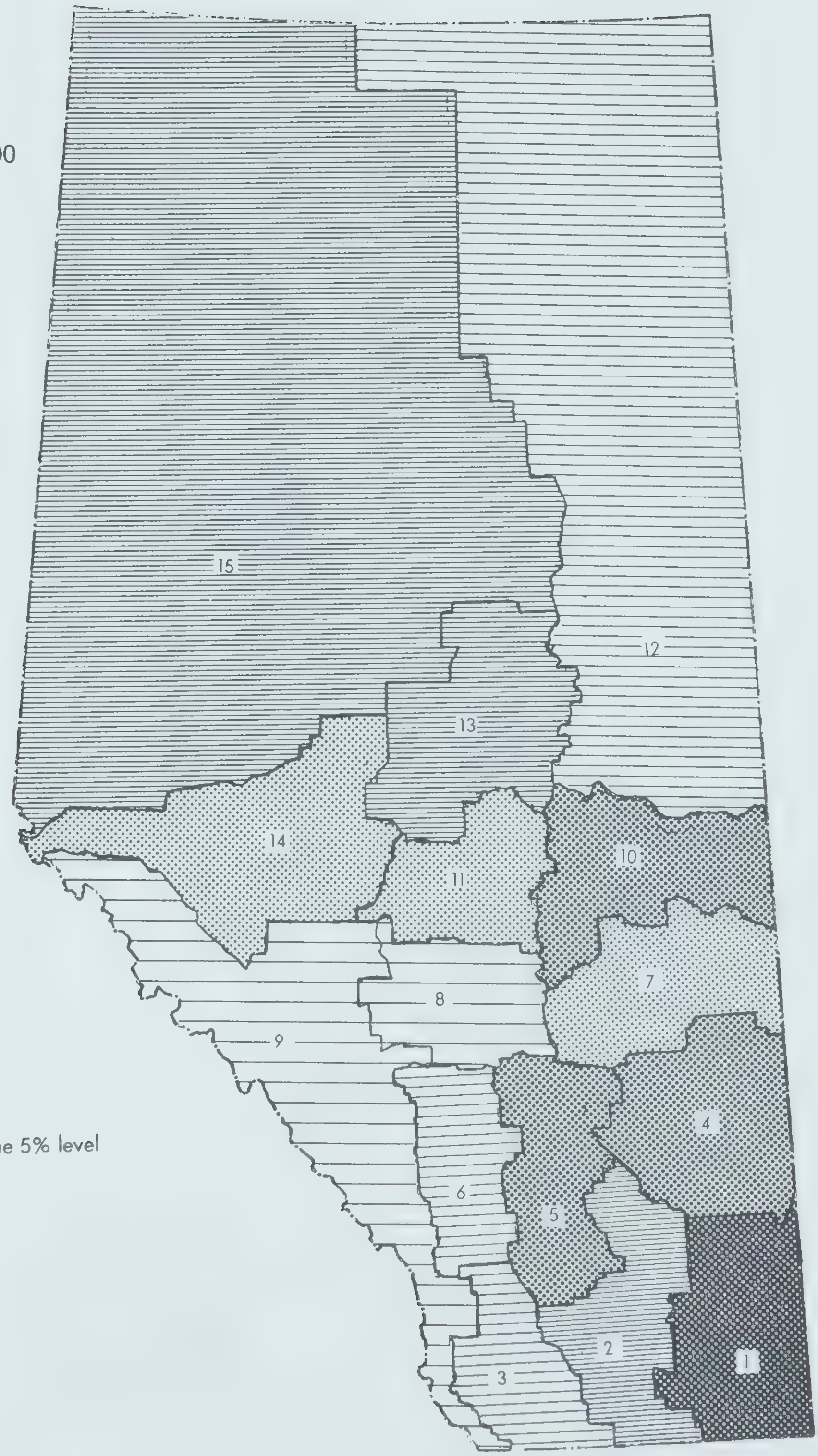


Figure 5

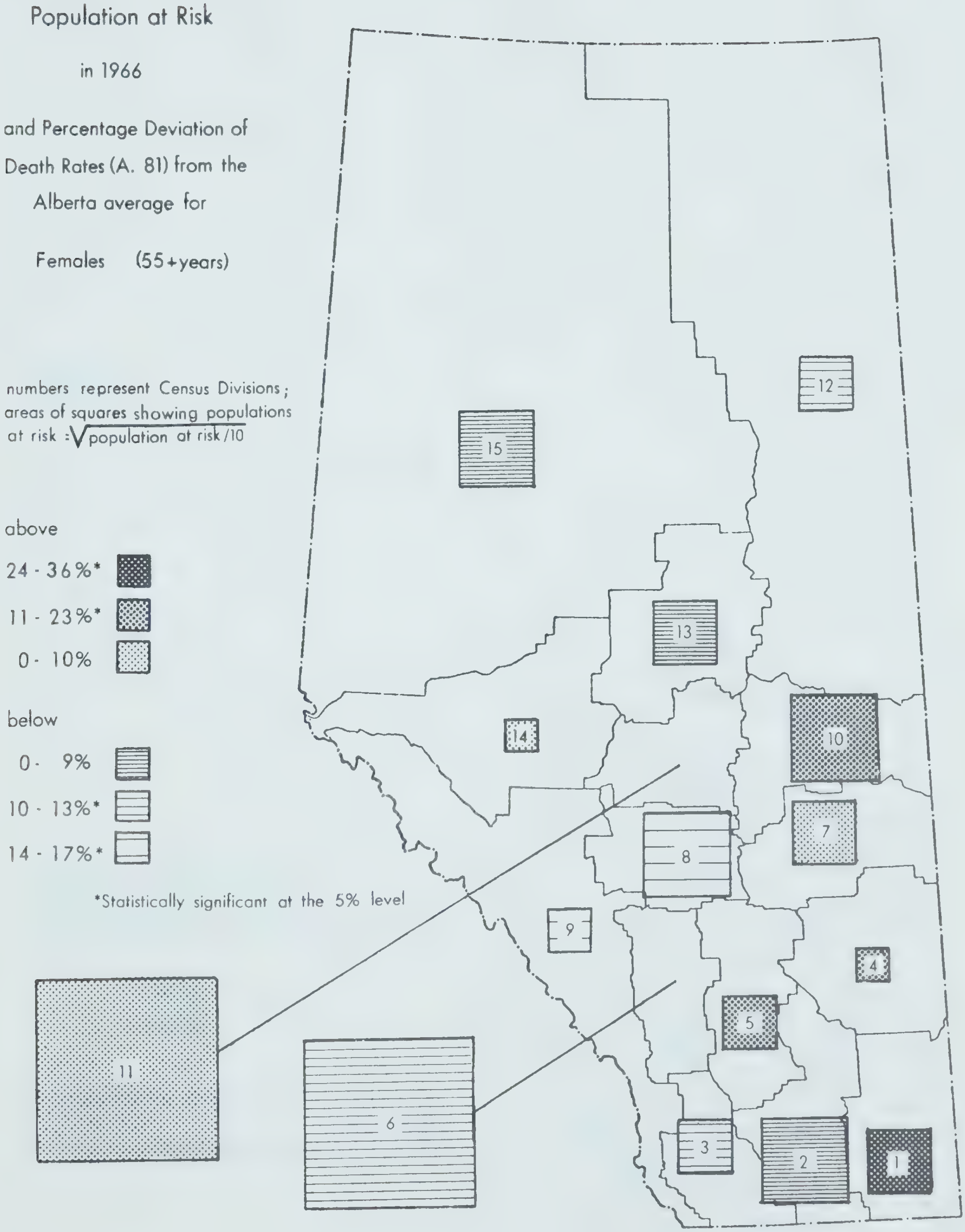

Population at Risk
in 1966
and Percentage Deviation of
Death Rates (A. 81) from the
Alberta average for
Females (55+years)
numbers represent Census Divisions;
areas of squares showing populations
at risk : √population at risk/10
above
24 - 36%*
11 - 23%*
0 - 10%
below
0 - 9%
10 - 13%*
14 - 17%*
*Statistically significant at the 5% level
15
12
13
14
10
7
8
9
4
5
11
6
3
2
1

Figure 6


ALBERTA
3
2
1
1
2
3
4
5
3
Distribution of death rate (A. 81)
percentage deviation from the
Alberta average by Census Divisions
for
Males
1964-68
1&2:significantly below average
3:average
4&5:significantly above average

Figure 7

Distribution of death rate (A. 81)
percentage deviation from the
Alberta average by Census Divisions
for
Females
1964-68

Figure 8

number 3. For both sexes, a statistically significant increase of mortality from A.81 is observable in the southern half of the province in a generally west to east direction for the period 1964-68. The similarity of spatial and directional trends of increase for both sexes must be noted.

In the eight municipalities under study a total of 7,278 persons died from heart disease A.81 during the five-year period 1964-68. 4,765 males and 2,513 females succumbed (table 4) during this time; that is 953 males and 502.6 females per year fell victim to this type of heart disease. These municipalities, therefore, suffered a loss of approximately 1.2 per cent of their male and 0.6 per cent of their female population annually, mostly men over 45 years and women over 55 years of age.

The age-adjusted death rates for the municipalities, based on the crude death rate per 100,000 population for the province are shown on table 5 in descending order. The range for males is from 215.21 to 349.43 and for females from 104.91 to 166.67 deaths per 100,000 population per year. Three municipalities, Camrose, Wetaskiwin and Medicine Hat, had statistically significant mortality rates above the average; and two municipalities, Red Deer and Calgary, show mortality rates below the average for the male population. For females only two

municipalities, Medicine Hat and Camrose had significant rates above the average, and two, Red Deer and Calgary, rates below the average. Edmonton, Lethbridge and Grande Prairie approximate the average mortality rates for the male population as do the municipalities of Lethbridge, Edmonton, Wetaskiwin and Grande Prairie for the female population.

The direction of increase in the spatial distribution of mortalities from A.81 is shown for each sex separately on isopleth maps (figure 9 and 10). Similar to the directional trend of mortality by Census Divisions, the increase in death experiences seems to follow, generally a west to east direction.

In the studies on the persistence of trend, using data for 1959-63, the total number of deaths from disease A.81 during the period was 11,810. Males experienced over twice as many deaths as females, 8,262 compared to 3,548 (table 7). The crude death rate per 100,000 for the male population in the province for 1961 was 239.05 and for females 102.40 (rounded to 239 and 102 respectively). The age-adjusted mortality rates for both sexes in the fifteen Census Divisions are listed on table 8 in descending order. The range of death rates for males is from 197.10 to 279.71 and for females from 85.06 to 136.76. Five Census Divisions had statistically significant death rates above the provincial average for males, and

ALBERTA

Distribution of death rate (A. 81) percentage deviation from the average for 8 municipalities,

Males
1964-68

1&2: significantly below average
3: average
4&5: significantly above average

Figure 9

ALBERTA

Distribution of death rate (A. 81)
percentage deviation from the
average for 8 municipalities ,

Females
1964-68

1&2: significantly below average
3: average
4&5: significantly above average

Figure 10

three Census Divisions significant rates below. For females seven Census Divisions had rates above, and one Census Division had a rate below the provincial average at the same significance level. The male population at risk in Alberta during the period numbered 166,114 in 1961, and the female population 81,819.

The percentage deviations from the Alberta average for males range from 17.03 above to 17.53 below, and for females from 34.08 above to 16.60 below the Alberta average for 1959-63 (table 8). This indicates a wider deviation range for females from the provincial rate than for males from the standard rates for the sexes.

The isopleth maps (figure 11 and 12) for male and female mortality deviations from the provincial average indicate for the southern half of the province a directional increase from west to east. Since the main purpose for studying the 1959-63 period is to investigate persistence in the spatial distribution patterns of disease A.81 over time from 1959-63 to 1964-68, a non-parametric test was performed to rule out chance occurrences in distribution similarities. The formula, Spearman's Rank Correlation Coefficient, is:

$$r_s = 1 - \frac{6 \sum d^2}{n^3 - n} \quad \ldots\ldots\ldots\ldots (2)$$

where d is the difference between ranks, and
n is the number of pairs.

ALBERTA

Distribution of death rate (A. 81)
percentage deviation from the
Alberta average by Census Divisions
for
Males
1959-63

1&2: significantly below average
3: average
4&5: significantly above average

Figure 11


ALBERTA
2
3
4
5
3
4
5
4
Distribution of death rate (A. 81) percentage deviation from the Alberta average by Census Divisions
for
Females
1959-63
1&2: significantly below average
3: average
4&5: significantly above average

Figure 12

It resulted in $r_s = 0.632$ ($p < 0.05$) for males and females equally. This value supports the confidence in assuming a persistency in mortality distribution patterns over time.

The overall persistence in mortality deviation patterns from the provincial average was further examined by a detailed comparison of the single Census Divisions. The categories 1 to 5, symbolizing the intensity of deviations used for the isopleth maps were chosen for comparisons rather than the actual percentage deviations, because they eliminate problems connected with numerical variations. Tables 9 and 10, and figure 13 show the Census Divisions and the categories of deviation intensities for the two study periods 1959-63 and 1964-68 for both sexes. Keeping in mind that categories above 3 imply a statistically significant deviation (in per cent intervals) above the Alberta average, and categories below 3 a significant deviation below, one may see that for males death rates were persistently high during the two periods, in Census Divisions 1, 4, 5 and 11. For females high mortalities were persistent in Census Divisions 1, 4 and 10. Low rates persisted for males in Census Division 6. No Census Division was persistently low during the two periods for females.

The mortality rates too close to the average to be significantly different, were persistent for males

Table 9: Categories for the percentage deviation ranges of mortality rates (A.81) from the Alberta average for males and females used for isopleth maps, Census Divisions 1959-63

Males

%-deviation above average	category	Census Division
14 - 20 **	5	4, 5, 11,
7 - 13 **	4	1, 14,
0 - 6		
below average	3 *	2, 7, 8, 9, 10, 12, 13,
0 - 6		
7 - 13 **	2	15,
14 - 20 **	1	3, 6,

Females

%-deviation above average	category	Census Division
22 - 35 **	5	1, 4, 10
8 - 21 **	4	2, 9, 11, 14,
0 - 7		
below average	3 *	3, 5, 6, 7, 8, 12, 13,
0 - 7		
8 - 15 **	2	15,

* average

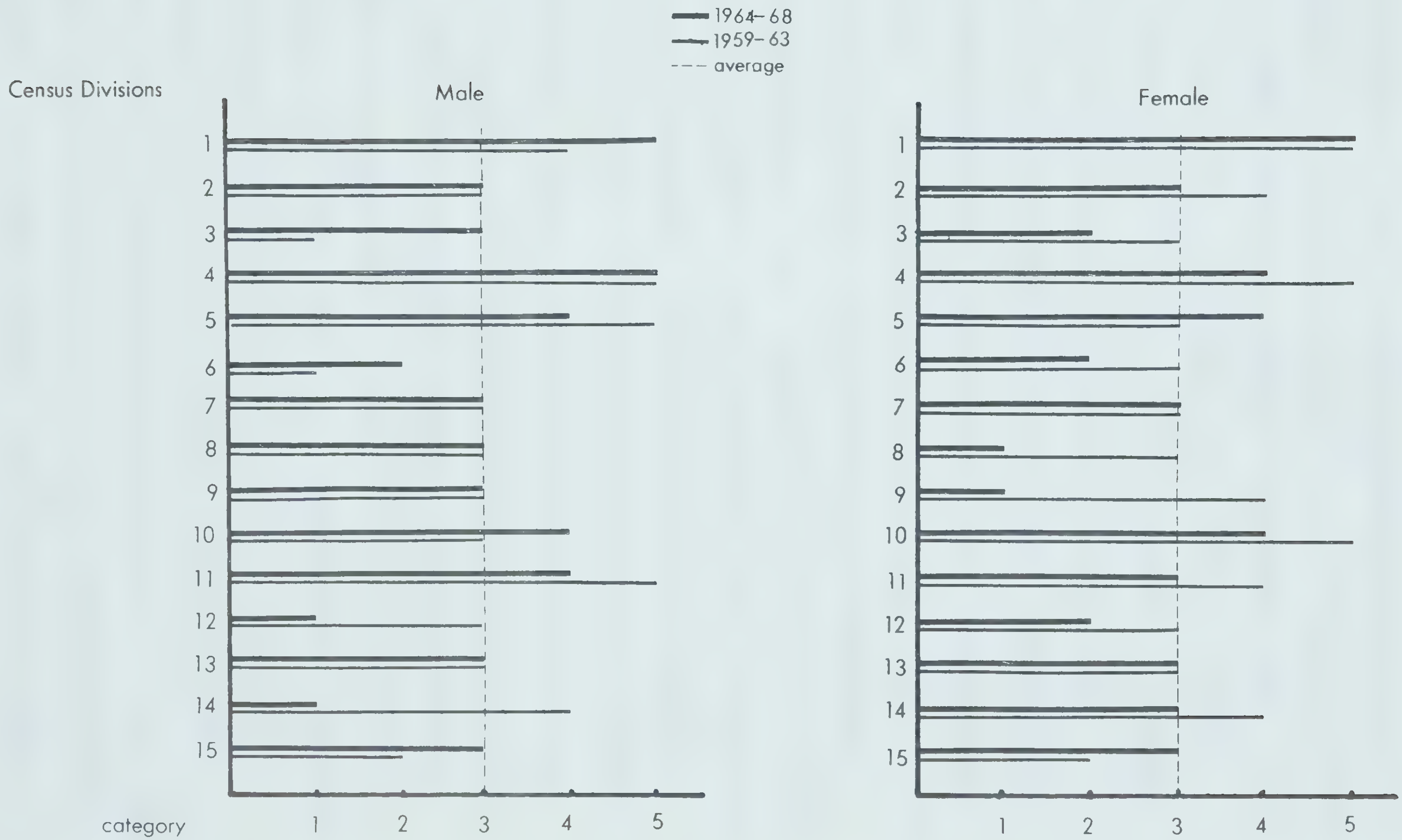
**statistically significant at the 5 per cent level

Table 10: Categories for the percentage deviation ranges of mortality rates (A.81) from the Alberta average for males and females by Census Divisions for the periods 1959-63 and 1964-68

Census Division	Category* 1959-63		1964-68	
	Males	Females	Males	Females
1	4	5	5	5
2	3	4	3	3
3	1	3	3	2
4	5	5	5	4
5	5	3	4	4
6	1	3	2	2
7	3	3	3	3
8	3	3	3	1
9	3	4	3	1
10	3	5	4	4
11	5	4	4	3
12	3	3	1	2
13	3	3	3	3
14	4	4	1	3
15	2	2	3	3

* 1 and 2 : significantly below the average
3 : average
4 and 5 : significantly above the average

Figure 13 Death rates (A. 81) deviation from the Alberta average by Census Divisions for Males and Females for 1959-63 and 1964-68, (categories: 1&2 significantly below, 3: average, 4&5: significantly above)



in Census Divisions 2, 7, 8, 9 and 13, and for females in Census Divisions 7 and 13. Males experienced an increase in mortality from A.81 over time in Census Divisions 3, 10 and 15, and females in Census Divisions 5 and 15. A decrease in mortality for males over time was found in Census Divisions 12 and 14, and for females in Census Divisions 2, 3, 6, 8, 9, 11, 12 and 14. Of greatest interest are the Census Divisions with persistently high mortality rates from heart disease A.81, for males Census Divisions 1, 4, 5 and 11, and for females Census Divisions 1, 4 and 10, all of which are located in the prairies and parkland region of the southeastern portion of Alberta.

It was expected from the outset that the spatial distribution of mortality rates from arteriosclerotic and degenerative heart disease in the Province of Alberta may be scattered, and that the mortality experiences in the Census Divisions may differ considerably as was observed in other countries (H.I. Sauer, 1962). Striking, however, are the geographical locations of areas with the highest and the lowest mortality occurrences for both sexes. Mortality rates significantly higher than the Alberta average for males and females occurred in the southeastern part of the province. In contrast, occurrences in the northeast and southwest of Alberta are the lowest for both sexes, and particularly, for the female population.

The possibility of migration factors, producing unaccountable changes in the age structure of Census Divisions and, with it, high mortality rates, was considered, by collecting five-year data straddling the 1966 (1961 for the earlier period) census year as is the practice in epidemiological research. The assumption is, that annual changes of populations from in- and outflow of people are averaged about a centerpoint in time. Since yearly population counts by sex and age are not available, this method has no alternative. The reliability of information obtained in this manner for a five-year period, and adjusted to age and sex, seems to be reasonably good for comparisons between Census Divisions, since annual fluctuations may cancel out one another (N.D. McGlashan, 1972).

The population at risk (1966) in the "problem" areas of highest mortality alone (males: Census Divisions 1, 4, 5, 10, 11; females Census Divisions 1, 4, 5, 10) numbered 77,696 males and 13,308 females, and amounted to 91,004 persons or six per cent of the total population in Alberta. All persons in Alberta at risk to succumb to disease A.81 in 1966 numbered 278,944, males plus females or 19 per cent of Alberta's population.

The Census Divisions 1, 4, 5 and 10 (and 11 for males) considered to be "problem" areas in the province, immediately raise interest and need for explanation,

especially since it could be shown that these areas persisted over time by the investigation of distribution patterns during an earlier five-year period. It was also found that mortality rates increased geographically from west to east in the southern half of Alberta. This directional trend is repeated by the geographical distribution of death rates in municipalities with over 5,000 population.

Another interesting aspect is the comparison of "problem" Census Divisions with Municipalities of significantly high mortality rates, and of Census Divisions and Municipalities with low death rates. The adjusted death rates per 100,000 for males and females in Census Divisions and Municipalities are listed on table 11. It can be seen that mortality rates for males in the Municipalities are higher in the "above average" group than in the respective Census Divisions in which the Municipalities are located. Male death rates belonging to the "below average" group, however, are lower than in the respective Census Divisions. Mortality rates for females in the "above average" group in Municipalities are also higher than in the Census Division of their location, but in the "below average" group, the Municipality of Calgary experienced a lower mortality rate than the Census Division 6 in which it is located, while Red Deer had a higher rate than the Census Division 8 in which it lies.

Table 11: Death rates (A.81) for Census Divisions and municipalities over 5,000 population in Alberta for males and females, 1964-68

Males

Census Division	Death rate p.100,000	Municipality over 5,000	(C.D.)	Death rate p.100,000
above average**				
1	304.11	Medicine Hat	(1)	332.18
4	294.89			
5	272.72			
11	264.15	Wetaskiwin	(11)	333.24
10	260.73	Camrose	(10)	349.43
average*				
2,3,7,8, 9,13,15,				
below average**				
6	218.85	Calgary	(6)	215.21
14	209.98			
12	204.21			
		Red Deer	(8)	227.38

Females

Census Division	Death rate p.100,000	Municipality over 5,000	(C.D.)	Death rate p.100,000
above average**				
1	161.23	Medicine Hat	(1)	166.67
10	137.71	Camrose	(10)	165.11
4	136.31			
5	133.53			
average*				
2,7,11,13, 14,15,				
below average**				
6	107.78	Calgary	(6)	104.91
12	107.12			
3	104.68			
8	102.25	Red Deer	(8)	106.18
9	100.09			

* average(rounded): Males 241 p.100,000
Females 120 p.100,000

**statistically significant at the 5 per cent level

These observations, suggesting a possible urban-rural relationship, will be taken into consideration later. Generally, it can be said, that a similarity exists in death experience extent between Census Divisions and the Municipalities under study. The groupings around the provincial average for males and females in Census Divisions and Municipalities are given on figure 14 and 15 respectively.

From the above it can be concluded that the mortality experiences from arteriosclerotic and degenerative heart disease in the Province of Alberta are not evenly distributed or scattered, but occur at a significantly higher rate in the prairie and parkland areas of the southern half of the province. Furthermore, a directional trend in increase of death rates seems to be observable from west to east, particularly in the southern part of the province for both sexes. This trend was found to be persistent over time by the study of two independent five-year periods. Equally, the "problem" areas of significantly higher death rates showed persistence over time. The death rates in Municipalities parallel the death rates in their respective Census Divisions in which they are located, and therefore, support the distribution patterns and directional trend of increase of mortality from this type of heart disease.

Figure 14 Death rate (A.81) deviations from the Alberta average for Males, 1964-68 in Census Divisions : ◯ and in 8 Municipalities: ●

Categories: 1&2: significantly below average

3: average

4&5: significantly above average

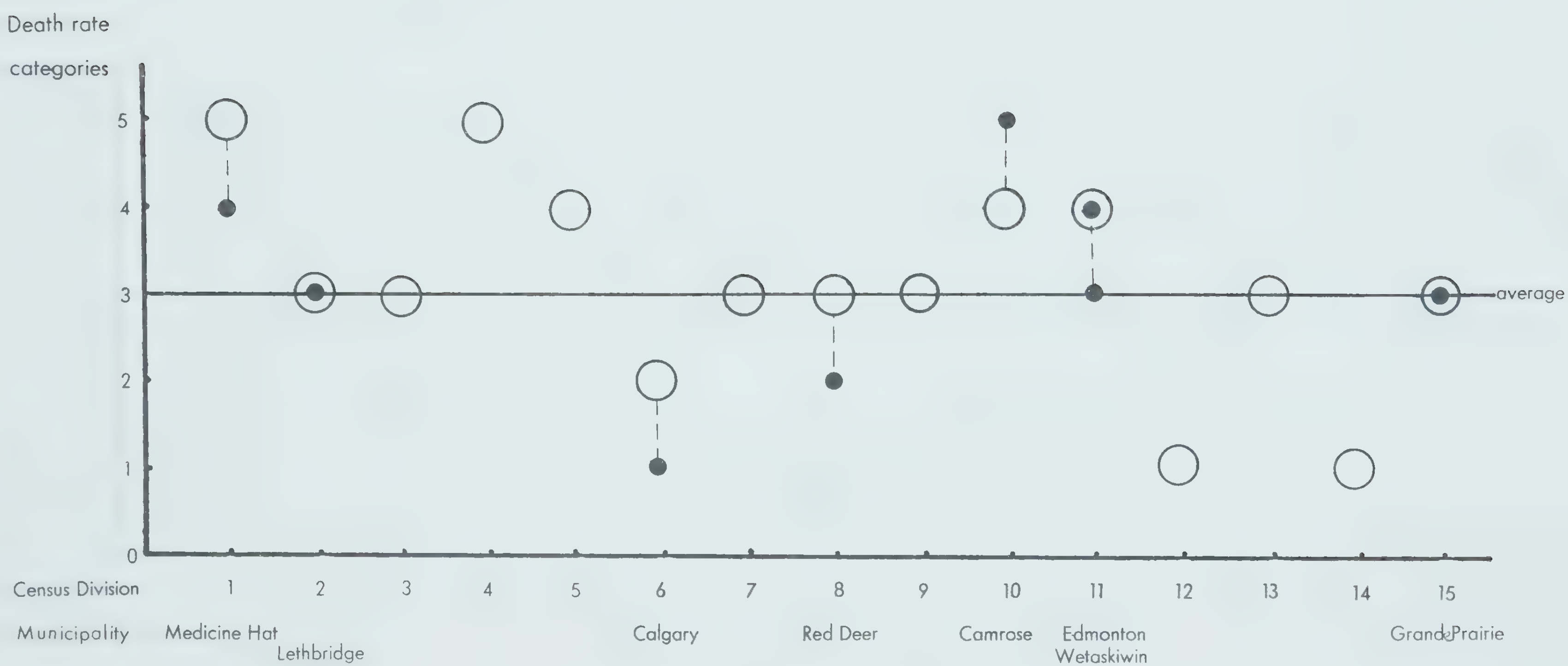
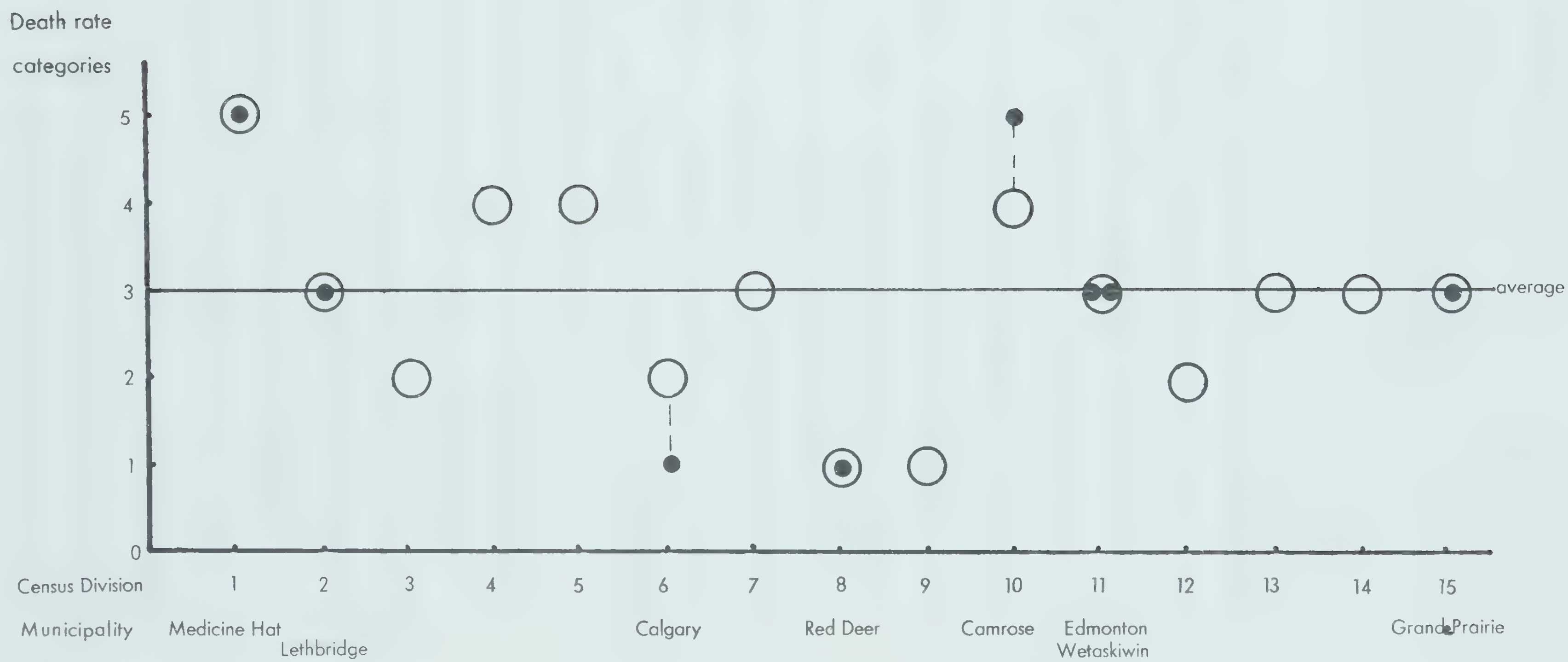


Figure 15 Death rate (A. 81) deviations from the Alberta average for Females, 1964-68 in Census Divisions : ◯ and in 8 Municipalities: ●

Categories: 1&2: significantly below average

3: average

4&5: significantly above average



CHAPTER IV

TESTS FOR ASSOCIATIONS BETWEEN ENVIRONMENTAL FACTORS AND DISEASE (A.81) MORTALITY

Death as the final consequence of pathogenesis, will here be studied mainly by consideration of physical, environmental factors, but some attention will also be given to a number of socio-economic factors of the environment, all of which are of geographical concern. It is not assumed that similarities between mortality distributions and the distribution of environmental factors will point to causalities for death occurrences from disease A.81; rather, that such similarities will uncover factors which may contribute, or which are perhaps instrumental in producing a high mortality incidence by exerting an additional stress upon an organism already at risk.

Stress, ofcourse, can be both, detrimental and favourable to an organism, depending upon the physical state of the organism and upon the type, quantity, quality and duration of stress applied to it. Persons at risk to lie from heart disease A.81 are to a certain degree physically and psychologically vulnerable to stress of all kinds, and are affected by it, often in a detrimental way. Persons at risk to die from disease A.81 by medical definition, are males over 45 years and females over

55 years of age, who are persons in the weakest stage of Selye's "General Adaptation Syndrome" (H. Selye, 1950), namely in the "stage of exhaustion" (H. Selye, 1956). In this "stage of exhaustion" aging and pathogenesis in an organism depress the fitness of the organism to withstand stress. A young and healthy organism's adaptability to stress can be measured by the effectiveness of its physiological regulations (F. Sargent II., 1964), which H. Selye groups in the "General Adaptation Syndrome" into stage 1: "the alarm reaction" and stage 2: "the stage of resistance" (H. Selye, 1950). In both these stages the organism produces adaptive physiological regulations while in the third stage (of "exhaustion") the organism must submit to stress due to ineffective physiological reactions.

The essence of man's fitness to withstand stress, therefore, is his stage of adaptability which depends upon many factors such as his age, pathogenic history (often not detectable and lingering below the clinical horizon), genetic characteristics, biochemical functions and so on. Arteriosclerotic and degenerative heart disease is suspected, by the medical profession, to begin early in life (R.E. Leslie, 1963), sometimes as early as infancy, progressing insidiously through time without clinical symptoms, and consequently weakening progressively a person's adaptive responses to stress. A stress factor

such as climate may assault the "homeostatic mechanism by triggering a combination of physical (and psychological) stimuli" (ibid.) to which a person is unfit to adapt, if his sympathetic defence mechanism and his heart, involved in defence against these stimuli, are malfunctioning (S.W. Tromp, 1963). For example, cold is thought to be a more potent stressor than heat on the cardiovascular system (R.E. Leslie, 1963). In the case of heat combined with high humidity there is an exception, because cardiac activity is thereby stimulated to generate above normal quantities of energy. The cardiac reserve, or the cardio-vascular system's measure of adaptability will limit the amount of the energy production, and may be exhausted more easily in non-healthy persons under marked strain than in healthy persons. Detailed physiological functions of the cardiovascular system and reactions of the system to diverse physical and psychological stressors are not discussed here since they belong in the field of medical science. It suffices to state that man and his environment cannot be separated and must be seen as one system which sometimes is described as human ecology (E.S. Rogers and H.B. Messinger, 1967) involving cultural connotations.

Environmental factors involved in the host-environment relationship, specified in chapter I, are complex in operation and may consist not only of materials

such as those included under agent factors but also of simple elements of climate, weather, geology, soils etc. The list can be inexhaustible, hence some of those factors which seem to be related to the ecology of heart disease A.81 will be investigated. The same applies to socio-economic factors such as urban-rural situations of populations, health service facilities etc. In selecting factors for consideration of their influence upon mortality distributions, one must take into account the availability of data.

For our purpose the following factors are chosen: aspects of weather and climate such as mean annual precipitation, mean annual number of days with precipitation, mean annual snowfall, sunshine hours per year, Chinook frequency per year, mean annual temperature ranges and climatic zones. Furthermore, water hardness and soils which are characteristic of the Albertan environment in which above and below average mortality experiences occur, are investigated. These are agents which are influenced strongly by climate and are a guide to the distribution of many of the basic requirements of man in either his food, drink, shelter or living space.

It is realized that annual averages are notorious for hiding monthly, weekly, daily and other extremes which by themselves could be of importance to the study

of heart disease mortality (H.C. Teng and H.E. Heyer, 1955). However, consideration of short-term variations or short-term averages of environmental factors cannot be used for correlation purposes because they are not comparable with the mortality data which are compiled on an annual basis. Therefore, environmental factors with the same time scale as the mortality data have to be used. The same is true for the chosen socio-economic factors which may be related to mortality distributions, e.g. the urban-rural ratio, health service facilities and population densities.

Another problem is that detailed measurements for only few environmental data are available for Census Divisions, and correlations between these and mortality data had to depend in some instances upon rather subjective generalization and averaging of magnitudes of the factors of the environment. Some data had to be grouped into categories for the sake of clarity in presentation. But since all investigations concerning mortality and environment were done on a small areal scale and the emphasis is to be on general spatial distribution trends of mortality deviations, these unavoidable, subjective approaches are assumed to be justifiable. The procedures of grouping or averaging data are shown on the appropriate tables which accompany the discussions of the correlation results.

All resulting associations of physical and socio-economic factors with mortality occurrences from heart disease A.81 can only be evaluated as an initial analysis, and as a starting point for further, more detailed studies, particularly of correlation pairs of high significance.

The sources for environmental data are indicated on figures and/or tables. They were collected from existing maps and other sources published by the Alberta Government, the University of Alberta and elsewhere. One exception is the data for water hardness. These were collected by questionnaires from the municipalities. They were weighted in accordance with the annual population served by each municipality during the period 1964-68. The calculated arithmetic mean of water hardness was then used for correlation tests with the death rates for heart disease A.81 in the corresponding municipalities. Water hardness deviations and their significance were calculated on the average of the eight municipalities since data for the whole province were not available. Tests for association for fourteen physical and socio-economic environmental factors were selected for their appropriateness to the type of data in question. Most physical data both in raw values and/or through their "best fit" regression line association were tested by parametric (r: correlation coefficient and student's t) or non-parametric means

(r_s: Spearman's coefficient). The soil correlation and all socio-economic factor associations could only be analyzed visually because detailed data for soils and other factors were not available.

Correlations between mortality incidences in different areas and the above mentioned environmental factors will be attempted by visual presentations, maps, charts, diagrams, tables etc. Whenever reasonable, statistical tests are carried out in order to propose tentative explanations for the A.81 mortality diversities in Alberta; statistical guide lines may then be investigated in the field, and by clinical and laboratory tests with the help of the medical profession for the purpose of isolating actual causality.

Weather and climate in Alberta vary considerably under the influence of latitude, altitude, distance from the Pacific Ocean from which the province is separated by the Cordilleran Mountain Range, and exposure to the Arctic region east of the Cordilleran chain. The leeward position of Alberta in respect to this chain, combined with the prevailing easterly trajectories of air masses from the west, south and north, provides for an overall continental climate with cold winters and short, cool summers. The Rocky Mountains at the southwestern border of Alberta, the foothills, and the plains experience, however, quite different degrees of continentality which is expressed

in the variation of vegetation cover and soil zones. The spatial diversity in weather and climate made correlations with the spatial distribution of mortality from heart disease A.81 possible, and lead to the assumption that the weather and climate in the province, if correlations with death rates could be established, may contribute an additional stress upon the people at risk to die from this type of heart disease.

Climate can be grouped into three zones: the zone of short cool summers, the zone of long cool summers, and the grassland zone. The distibution of these zones, numbered from 1 to 3 with respect to increasing temperature and aridity (figure 16) was found to be associated with the distribution of death rates in a positive way; for males r= 0.786, and for females r= 0.598. The regression lines (figure 17) show an increase of mortalities with an increase in aridity and temperature. The similarity in directional, spatial trend can be seen by comparing figure 16 with figures 7 and 8. The investigations of other climate related elements gave the following results: Mean annual precipitation distribution (in inches) over the province correlated negatively with the distribution of death rates as shown in figure 18. Comparison of the isopleth maps figures 7 and 8 with figure 19 shows similar patterns of distribution of both variables. The general west-east trend of decrease in precipitation in the


ALBERTA
1
2
1
2
3
Climatic Zones
1 short cool summer
2 long cool summer
3 grassland
source: "Alberta, A Natural History",
W. G. Hardy (ed.), 1967

Figure 16

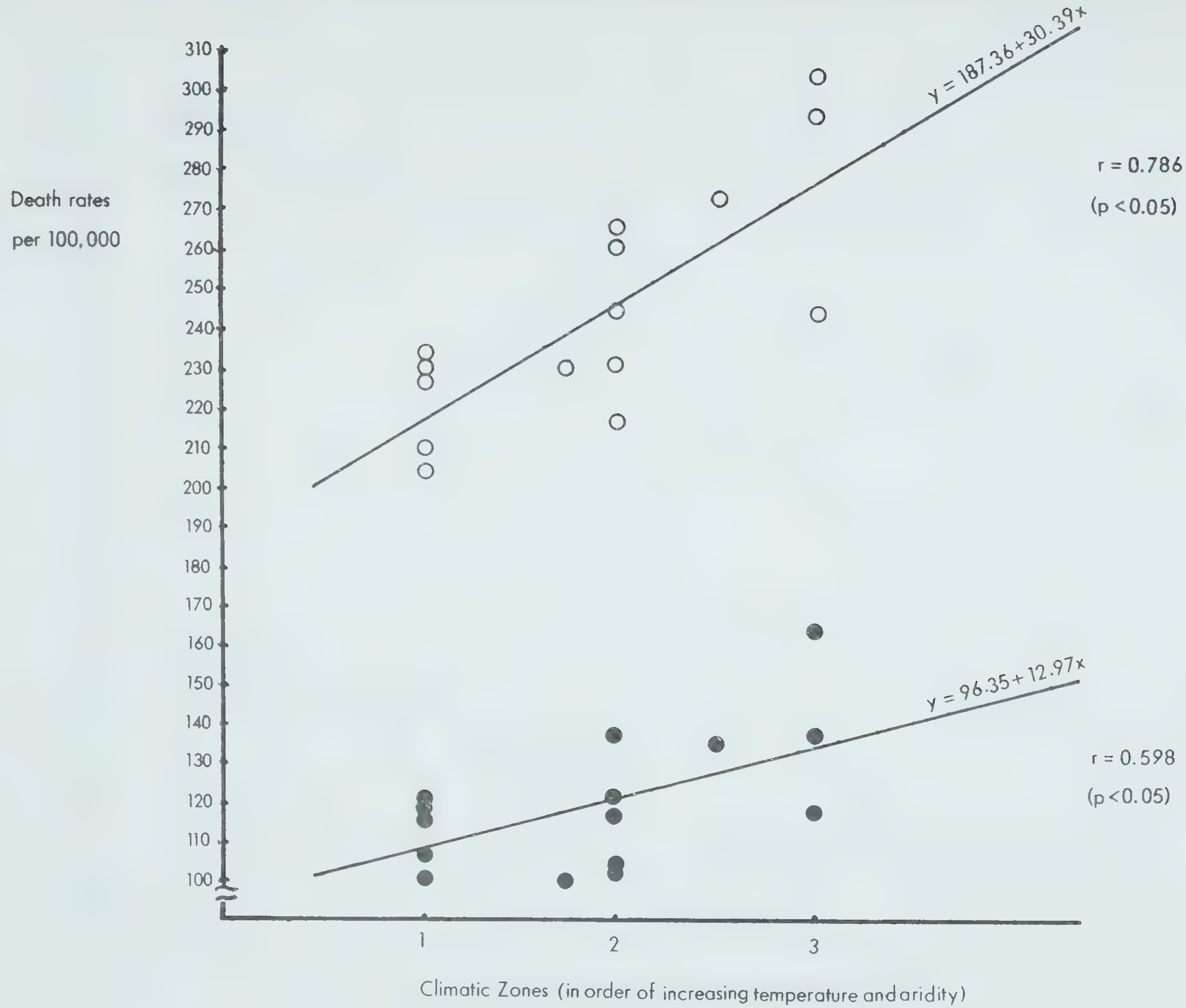


Figure 17 Death rates (A. 81) and Climatic Zones

O Males ● Females

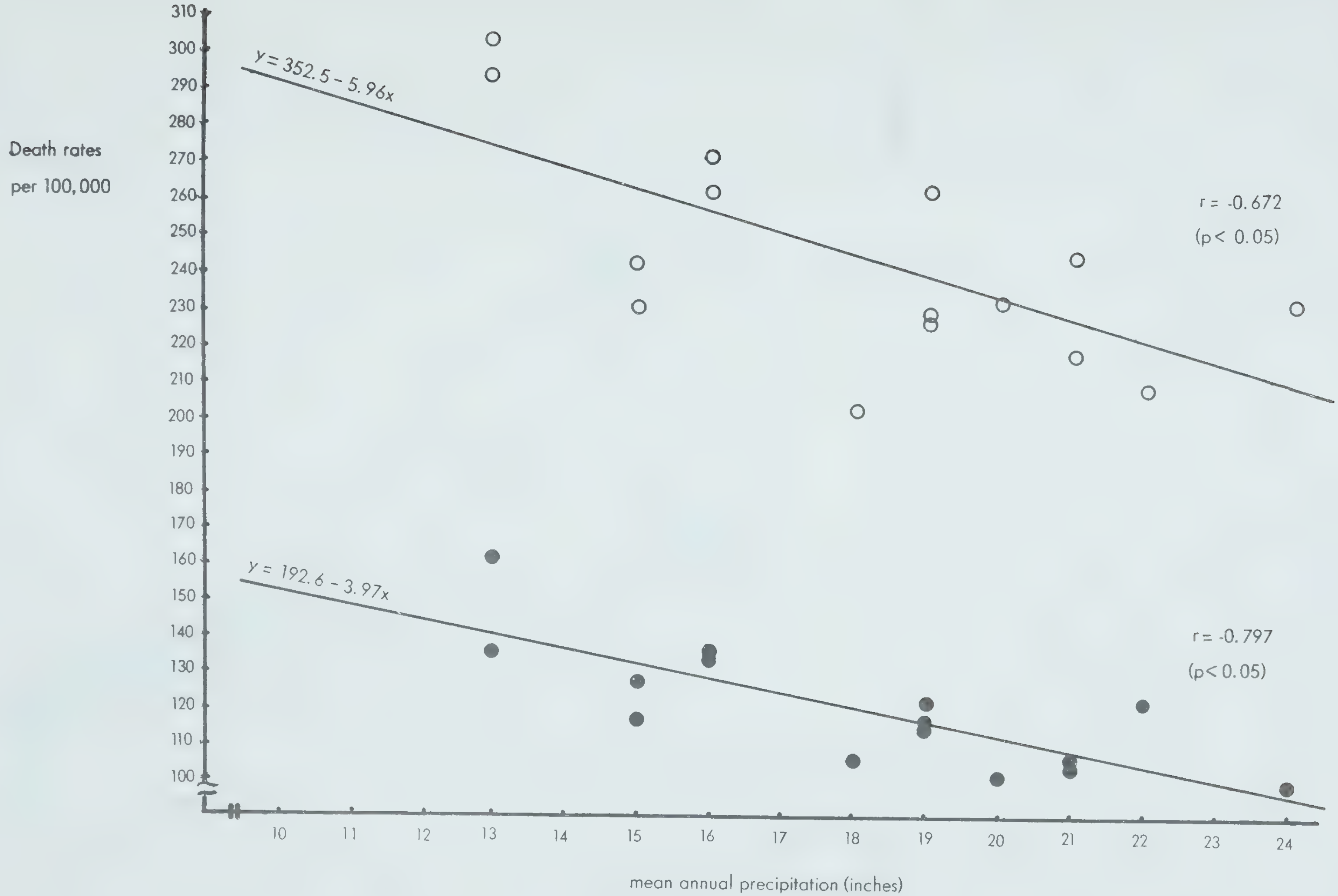


Figure 18 Death rates (A. 81) and mean annual precipitation (inches)

○ Males ● Females

ALBERTA

Mean annual precipitation (inches)

source: Government of Alberta, Dept. of Agriculture

Figure 19

southern half of the province parallels the increase in death rates for both sexes. The statistical tests for males and females resulted in r= -0.672 and r= -0.797 respectively (figure 18).

The mean annual number of days with precipitation, grouped into categories of increasing values from 1 to 6, correlated also, negatively, with the death rate distribution; r= -0.703 for males, and r= -0.572 for females (figure 20). A comparison of figure 21 with figures 7 and 8 will show the similarity of distribution trends.

Again, the correlation of the mean annual snowfall distribution (inches) with the death rates for both sexes was found to be negative and significant (figure 22). By comparing figures 7 and 8 with figure 23, the trend of decreasing annual snowfall from roughly west to east one can see a trend of increase in mortality. The correlation for males was calculated as r= -0.632, and for females r= -0.654.

The distribution of sunshine hours per year in Alberta, grouped into ascending order of categories from 1 to 6, is shown on figure 24. A positive correlation with the distribution of death rates for both sexes was found (figure 25), and a similarity in distribution patterns can be observed by comparing figure 24 with figures 7 and 8. The number of hours with sunshine increases

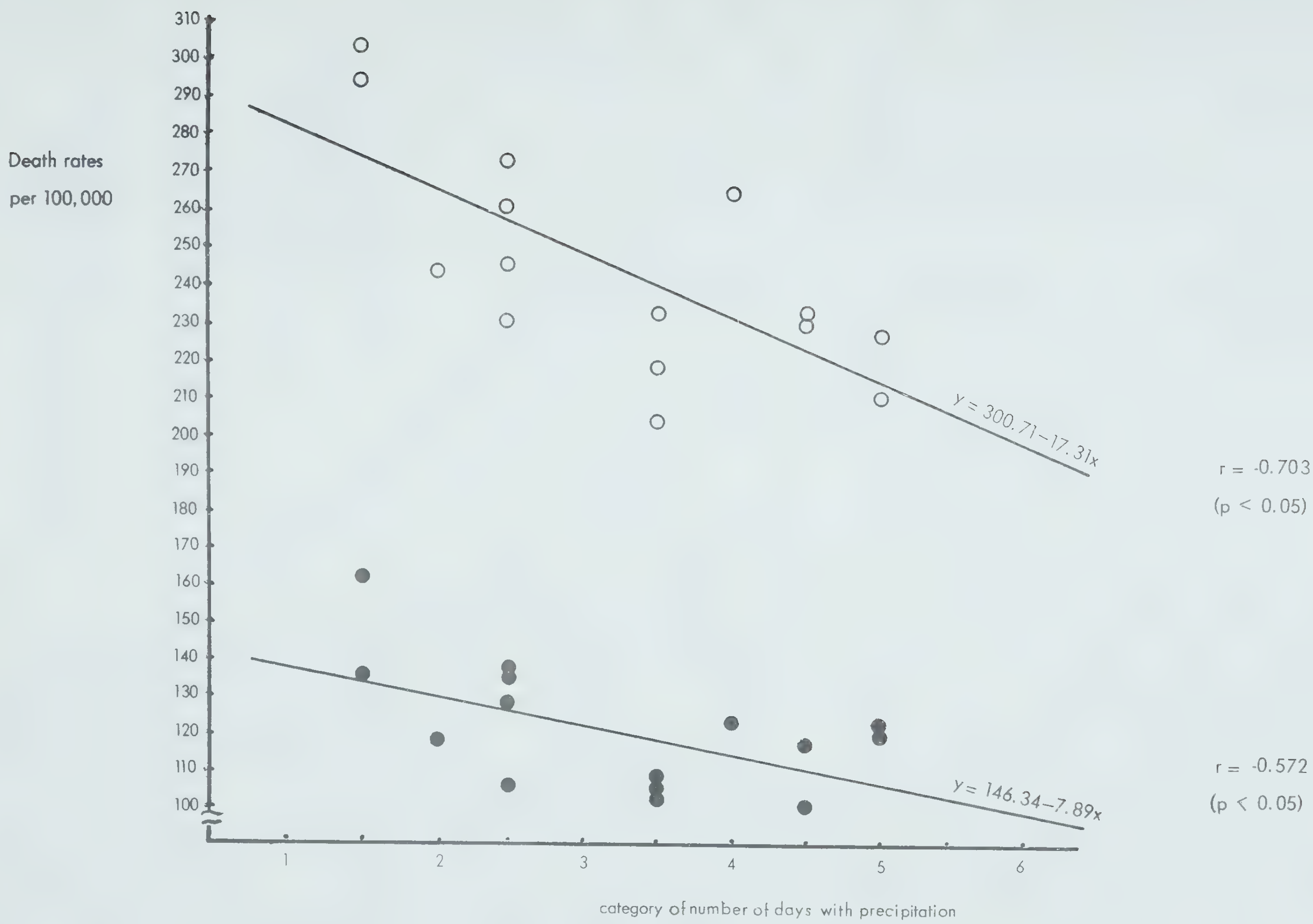
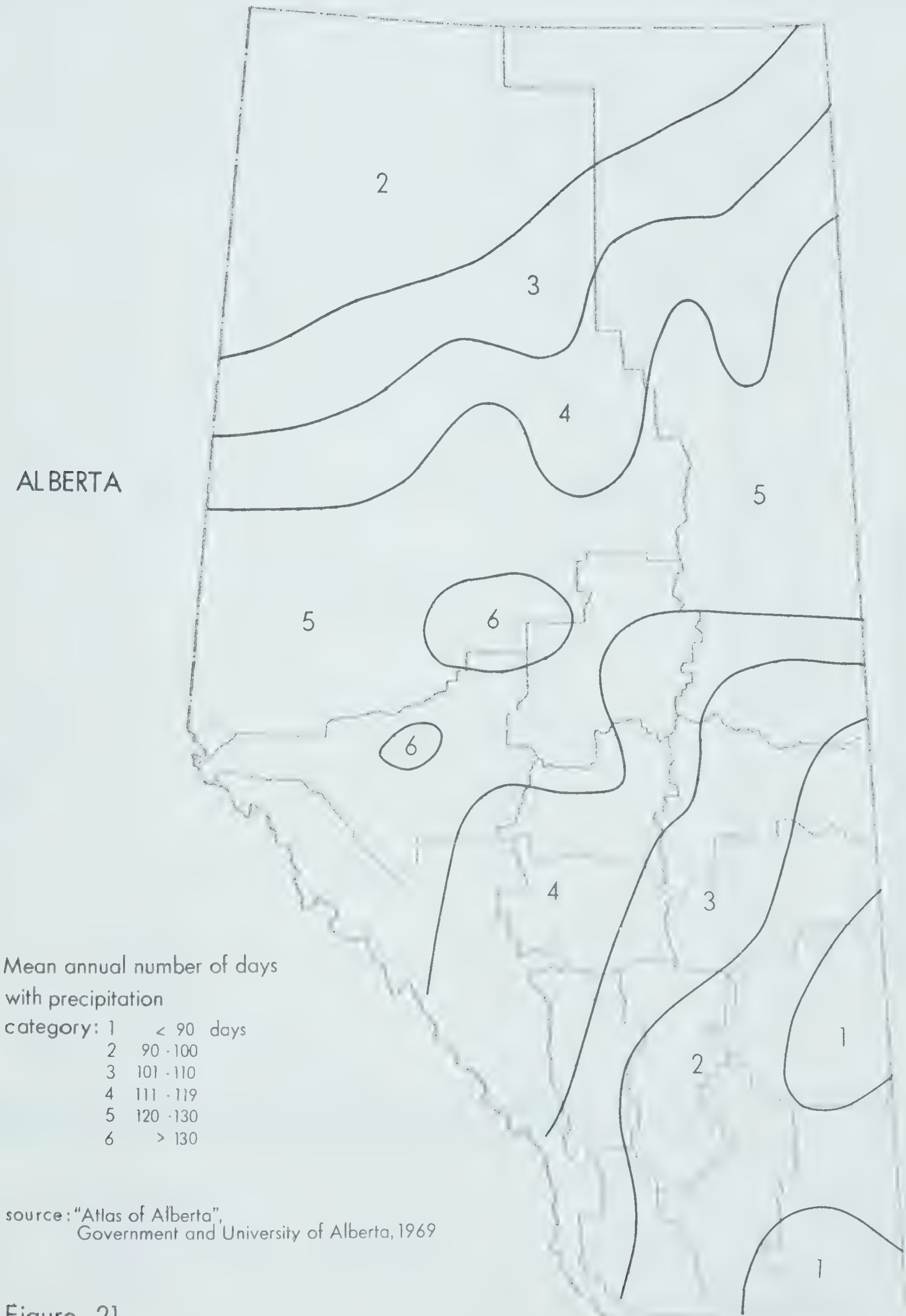


Figure 20 Death rates (A. 81) and Mean annual number of days with precipitation
O Males ● Females



source: "Atlas of Alberta",
Government and University of Alberta, 1969

Figure 21

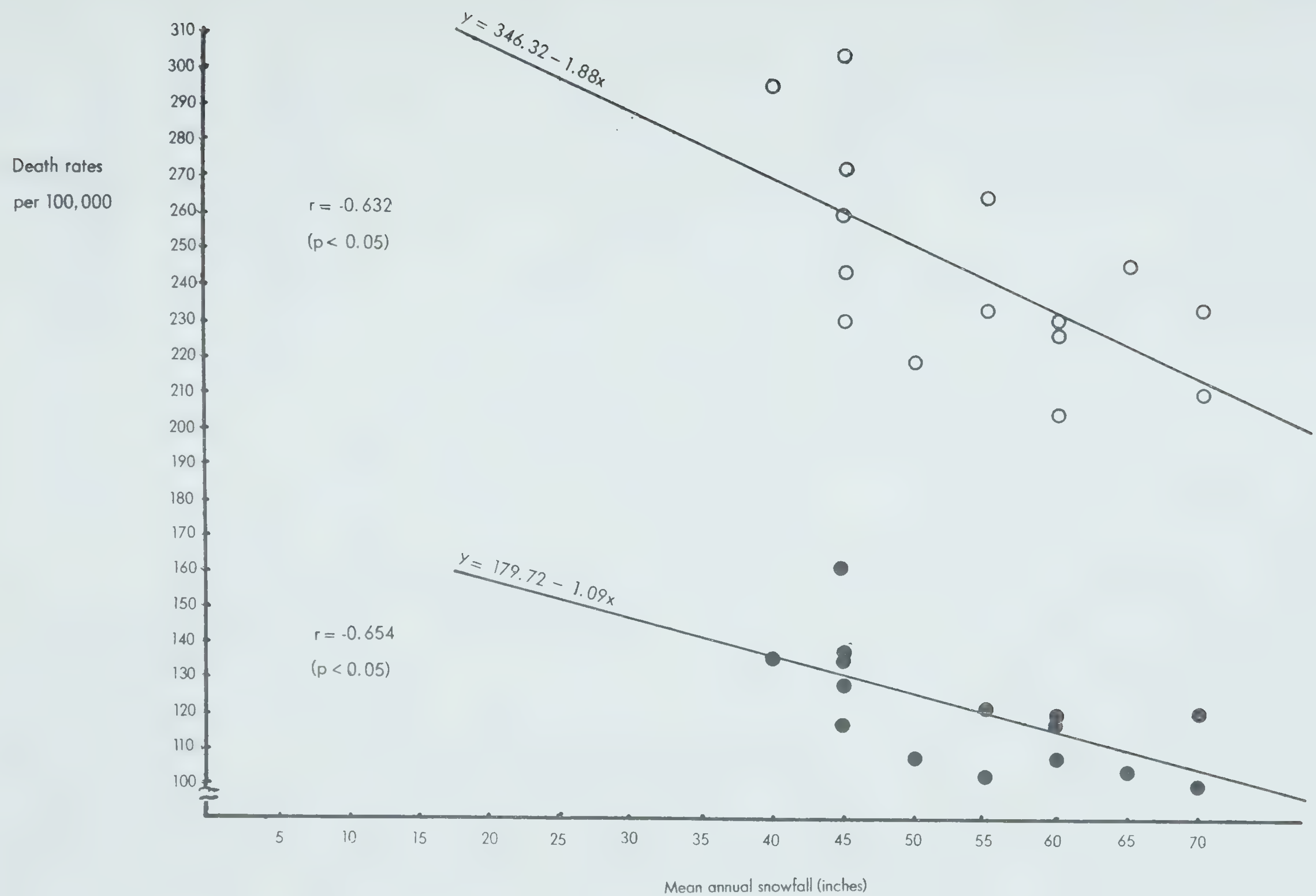


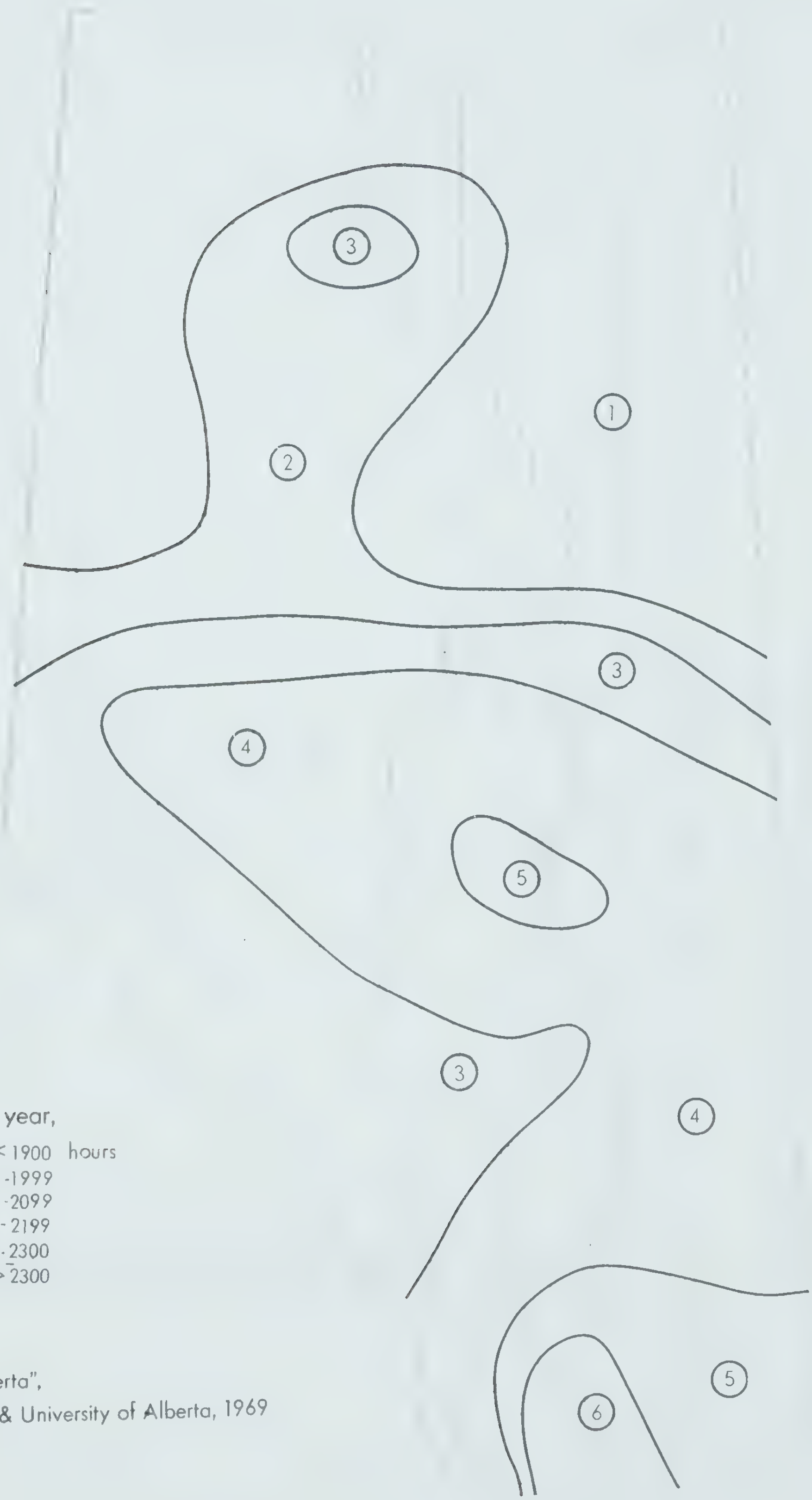
Figure 22 Death rates (A. 81) and mean annual snowfall (inches)
O Males ● Females

ALBERTA

Mean annual snowfall (inches)

source: "Alberta, A Natural History"
W. G. Hardy (ed.), 1967

Figure 23



Sunshine hours per year,

category: 1 < 1900 hours
2 1900 - 1999
3 2000 - 2099
4 2100 - 2199
5 2200 - 2300
6 > 2300

source: "Atlas of Alberta",
Government & University of Alberta, 1969

Figure 24

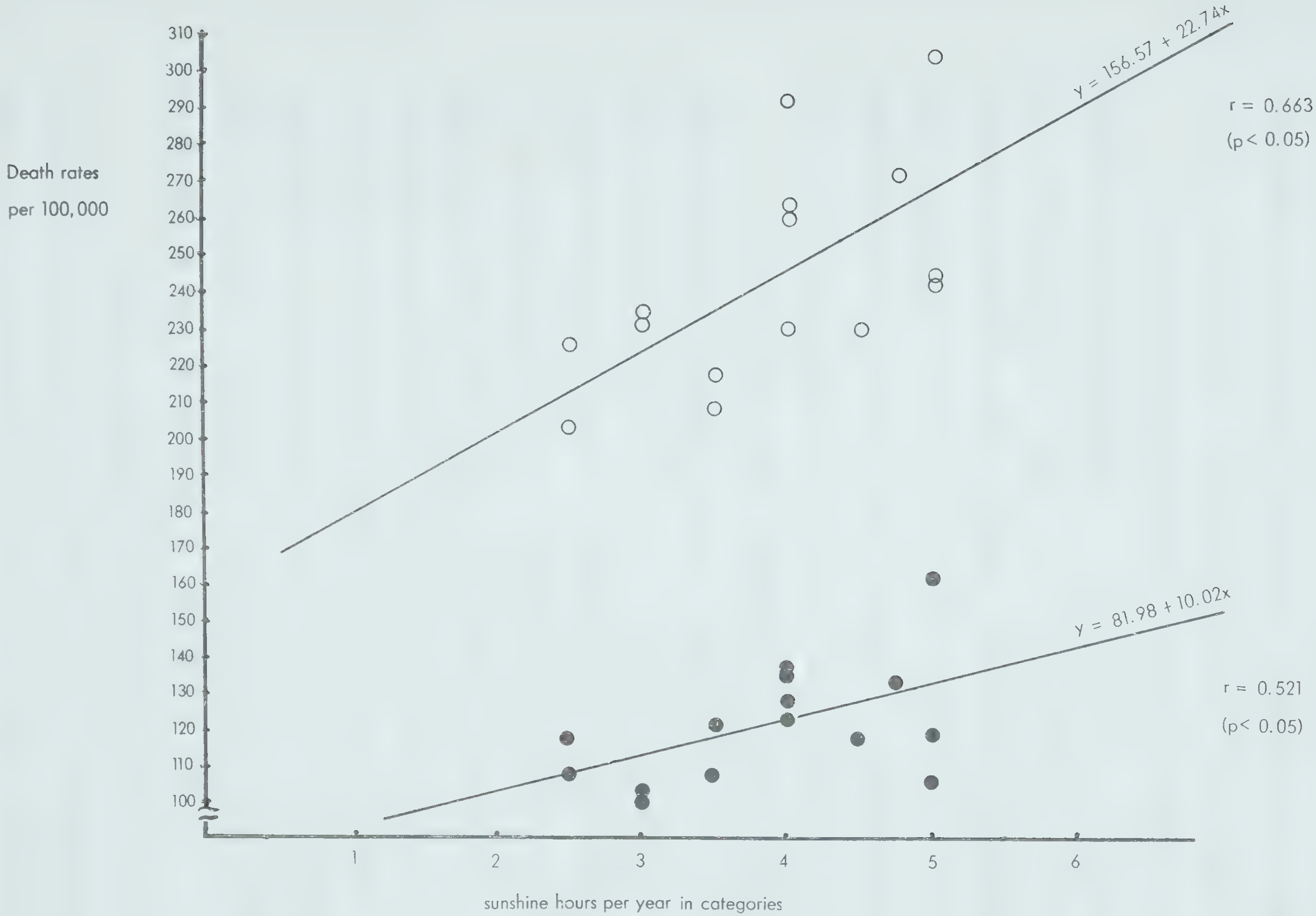


Figure 25 Death rates (A. 81) and Sunshine hours per year

O Males ● Females

in the southern half of Alberta from approximately west to east, however, the trend of the pattern is not very pronounced or regular. For males a correlation coefficient of r= 0.663, and for females of r= 0.521 was calculated.

The correlation test for the Chinook frequency distribution (figure 26) in the province, expressed as days per year with temperatures of 40^{o}F or over in the winter revealed no association. Comparing figures 7 and 8 with figure 27 varifies this association. Spearman's coefficient (r_s) tests for correlations resulted in r_s= 0.311 for males and r_s= 0.168 for females.

The mean annual temperature range distribution in the province (figure 28) was tested for correlation with death rate distribution, also by the Spearman's coefficient test, after averaging the temperature ranges for each Census Division. Although, a comparison between figures 7 and 8 and figure 28 seems to reveal a similarity in directional trend of temperature range increase and increase in mortality rates, the scatter diagram (figure 29) indicated no association. The non-parametric tests for males produced non-significant values of r_s= -0.09, and for females r_s= 0.40.

It was mentioned above that weather and climate influence water and soil quality. An investigation of water and soil distribution in comparison with death rate distribution, therefore, is of interest especially since

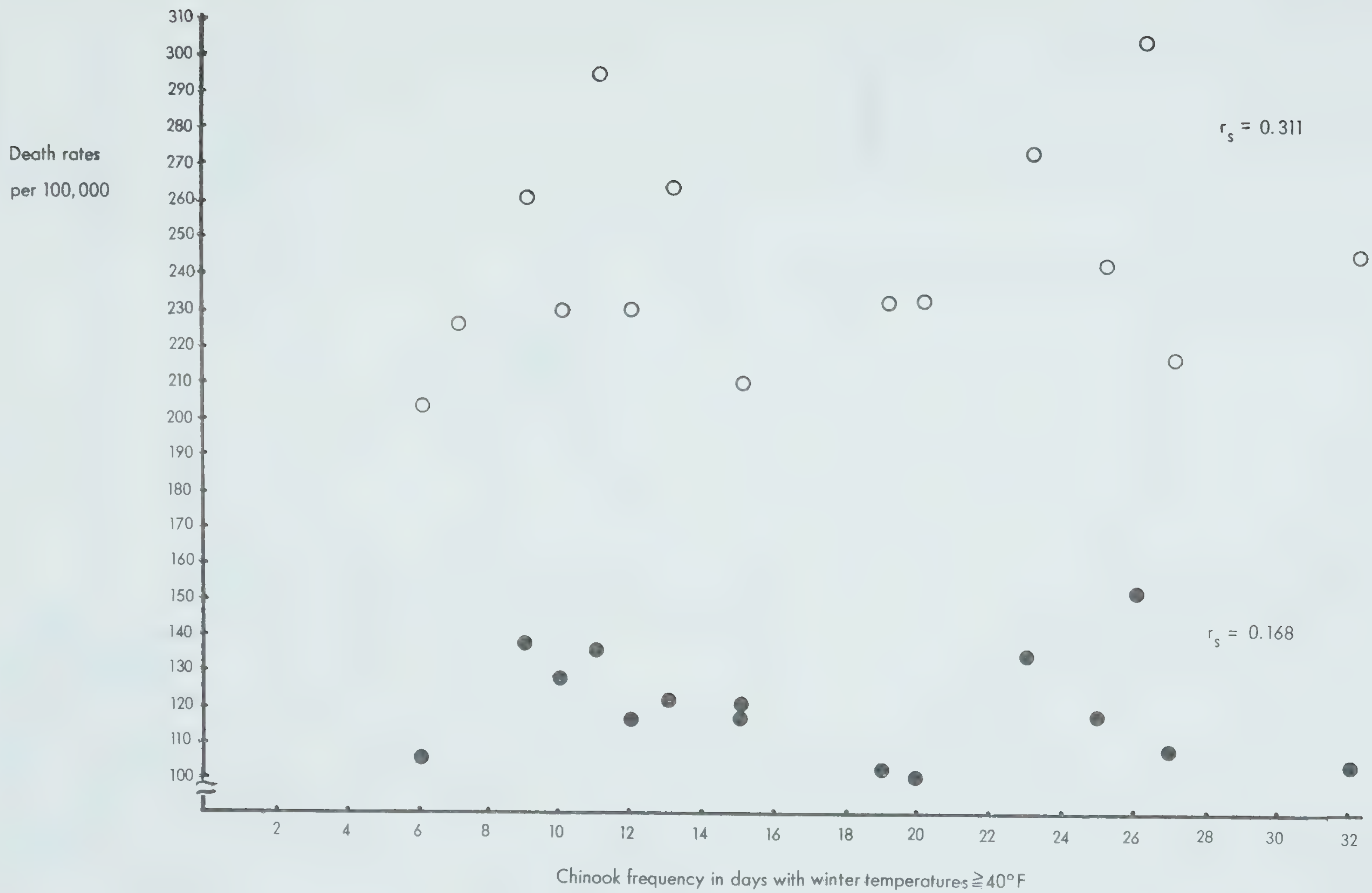
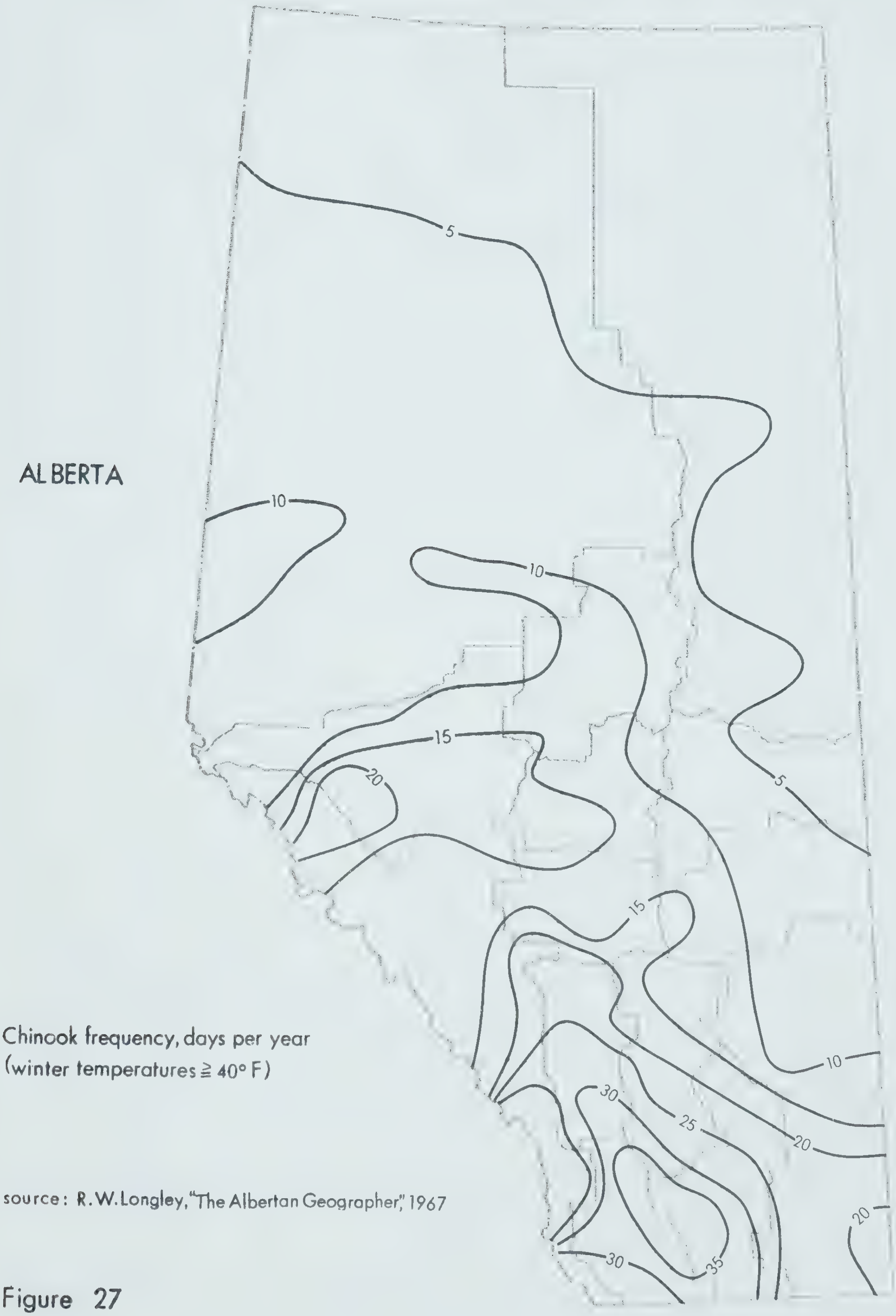


Figure 26 Death rates (A. 81) and Chinook frequency

○ Males ● Females



Chinook frequency, days per year
(winter temperatures ≧ 40° F)

source: R.W. Longley, "The Albertan Geographer," 1967

Figure 27

Mean annual temperature range (°F)

source: 'Atlas of Alberta', Govt. and University of Alberta, 1969

Figure 28

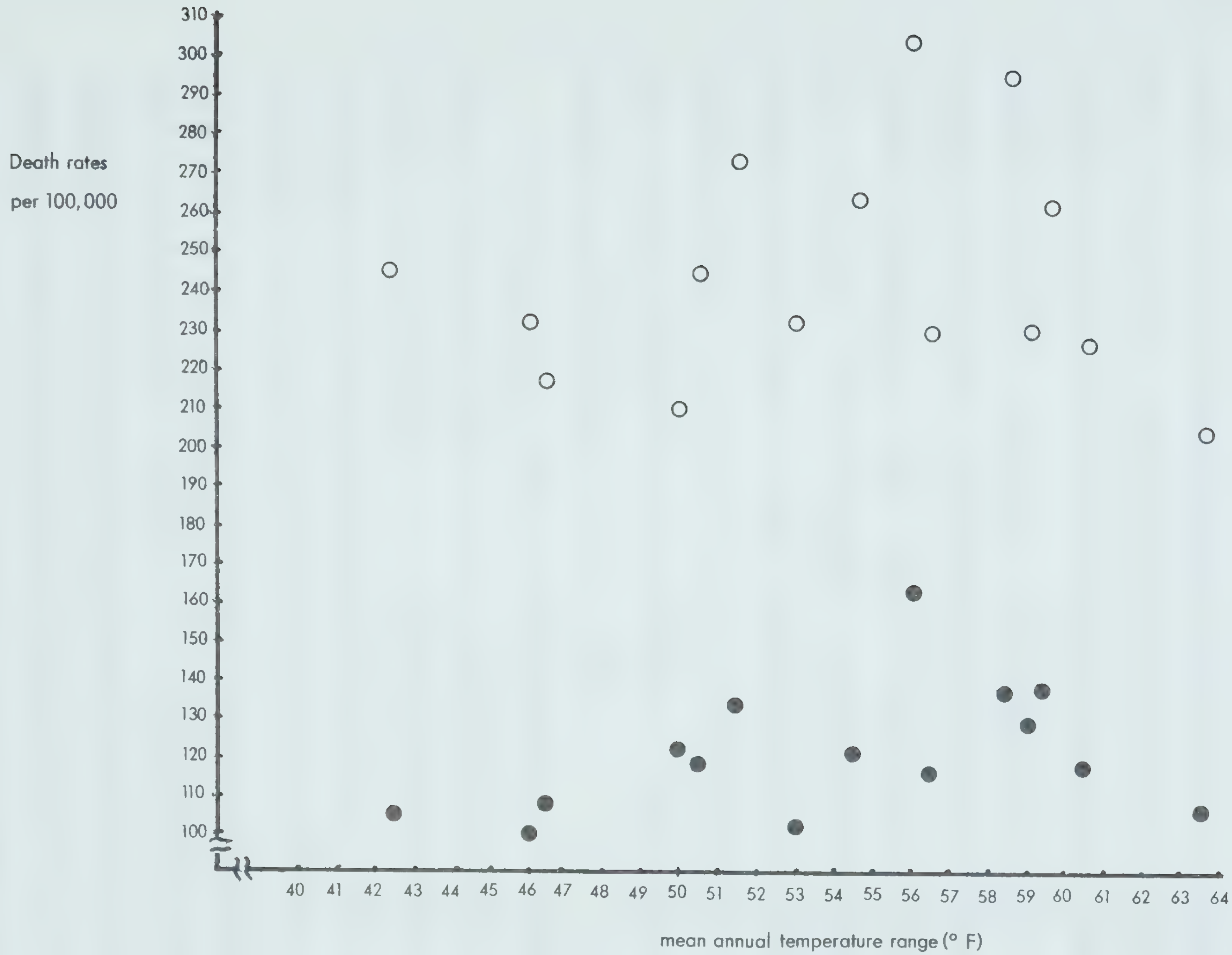


Figure 29 Death rates (A. 81) and Mean annual temperature range

○ Males ● Females

water in respect to hardness and soil in respect to salinity are characteristics of the Alberta environment in which above average and below average death experiences occur. Both these environmental factors are assumed, by other researchers referred to in chapter one, to be influential to high mortality experiences. The water hardness data for municipalities (table 12) and their respective mortality rates were plotted on a scatter diagram (figure 30). Male death rates seem to correlate negatively with water hardness, except for two municipalities. Female death rates, however, are scattered. Testing did not establish any statistically significant correlation between water hardness and the incidence of mortalities from heart disease A.81.

Figure 31 shows the distribution of solonetzic soils in Alberta. Statistical correlation between the distribution of these soils and the distribution of mortality rates was not attempted. Instead, the death rates for the Census Divisions by sex were listed in ascending order (table 13) under headings describing their locations on solonetzic or non-solonetzic soils. The death rates significantly below and above the Alberta average, marked by asterisks, clearly identify, for both sexes, a distribution pattern. All death rates significantly below the Alberta average are located in Census Divisions without solonetzic soils, while death rates

Table 12: Death rates (A.81) in eight municipalities in Alberta for males and females and water hardness (p.p.m.), 1964-68

Municipality	Death rate p.100,000		Water hardness(ppm)
	Males	Females	
Wetaskiwin	333.244+*	122.535	51.70-*
Edmonton (incl.St.Albert)	272.542	124.114	81.15-*
Red Deer	227.377-*	106.160-*	125.00
Lethbridge	252.174	125.118	135.00
Grande Prairie	247.779	121.473	150.00
Medicine Hat	332.183+*	166.667+*	160.00
Calgary	215.210-*	104.914-*	205.70+*
Camrose	349.425+*	165.109+*	237.70+*

+* significantly above average

-* significantly below average

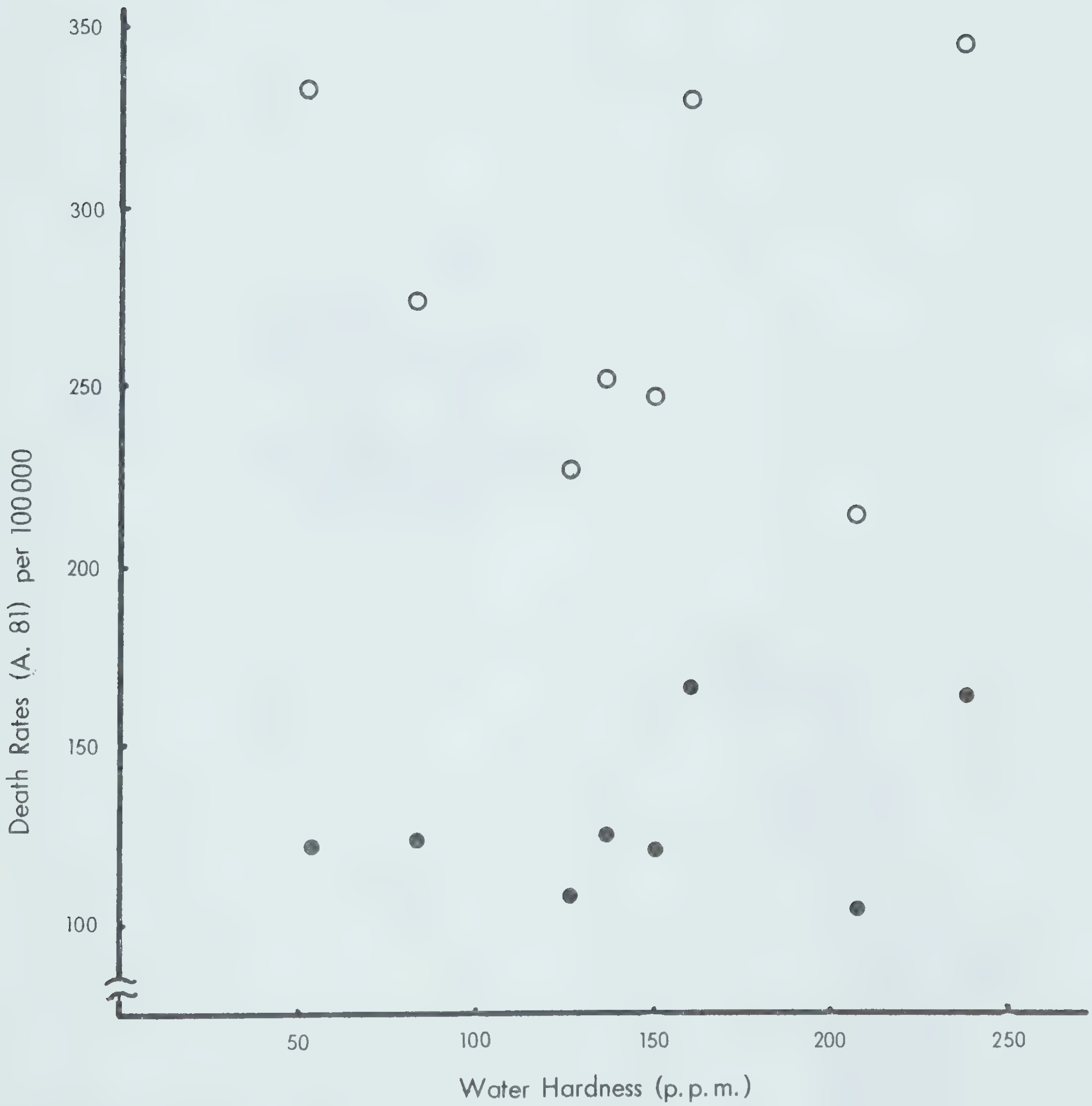
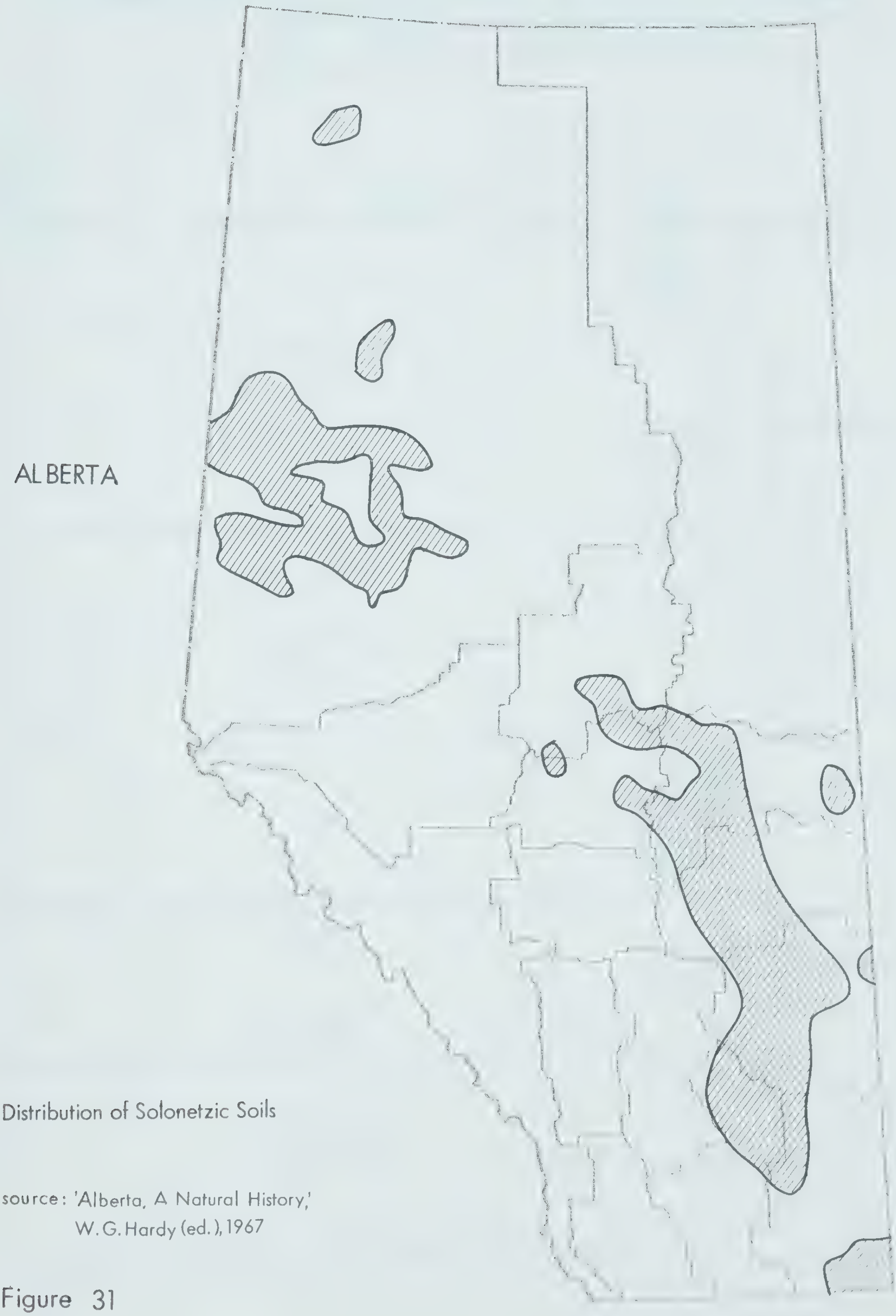


Figure 30 Scatter diagram for Death Rates and Water Hardness for 8 Municipalities in Alberta, O : Males ● : Females



Distribution of Solonetzic Soils

source: 'Alberta, A Natural History,'
W.G. Hardy (ed.), 1967

Figure 31

Table 13: Death rates (A.81) by Census Divisions, 1964-68, for males and females in areas with solonetzic soils and without solonetzic soils

Males

Census Divisions	Death rate p.100,000 solonetzic soils	non-solonetzic soils	
12		204.21 *	
14		209.98 *	
6		218.85 *	
15	226.60		
13	230.10		
7	230.10		
8		231.83	average
9		233.40	
2		244.39	
3		246.19	
10	260.73 *		
11	264.15 *		
5		272.72 *	
4	294.89 *		
1	304.11 *		

Females

Census Divisions	solonetzic soils	non-solonetzic soils	
9		100.09 *	
8		102.25 *	
3		104.68 *	
12		107.12 *	
6		107.78 *	
13	117.28		
15	117.51		
2		117.94	average
14		120.59	
11	121.28		
7	127.62		
5		133.53 *	
4	136.31 *		
10	137.71 *		
1	161.23 *		

* significantly above or below the average

significantly above the province's average occur in Census Divisions where solonetzic soils are present. The only exception is Census Division 5 with significantly higher death rates and the location in an area without solonetzic soils. The distributions of average death rates fall into areas of both types, with and without solonetzic soils.

Besides the physical environment, the socio-economic situation is recognized by epidemiologists as a potential force of influence to mortality occurrence from all disease and from heart disease A.81 (J.P. Fox et al., 1970). Some of the socio-economic factors in the environment, therefore, are investigated for a possible similarity in distribution patterns with the distribution patterns of mortality from A.81 in Alberta. The urban-rural ratio in the Census Divisions and their respective mortality rates were plotted on a scatter diagram (figure 32). No distribution trends are indicated, and the correlation tests for males ($r_s = -0.04$) and for females ($r_s = -0.27$) showed no significance between death rates and the urban or rural character of the Census Divisions.

The distribution of health service facilities was tested for correlation with death rates in the Census Divisions. This was of three types: distribution of physicians and surgeons, of nursing and auxiliary

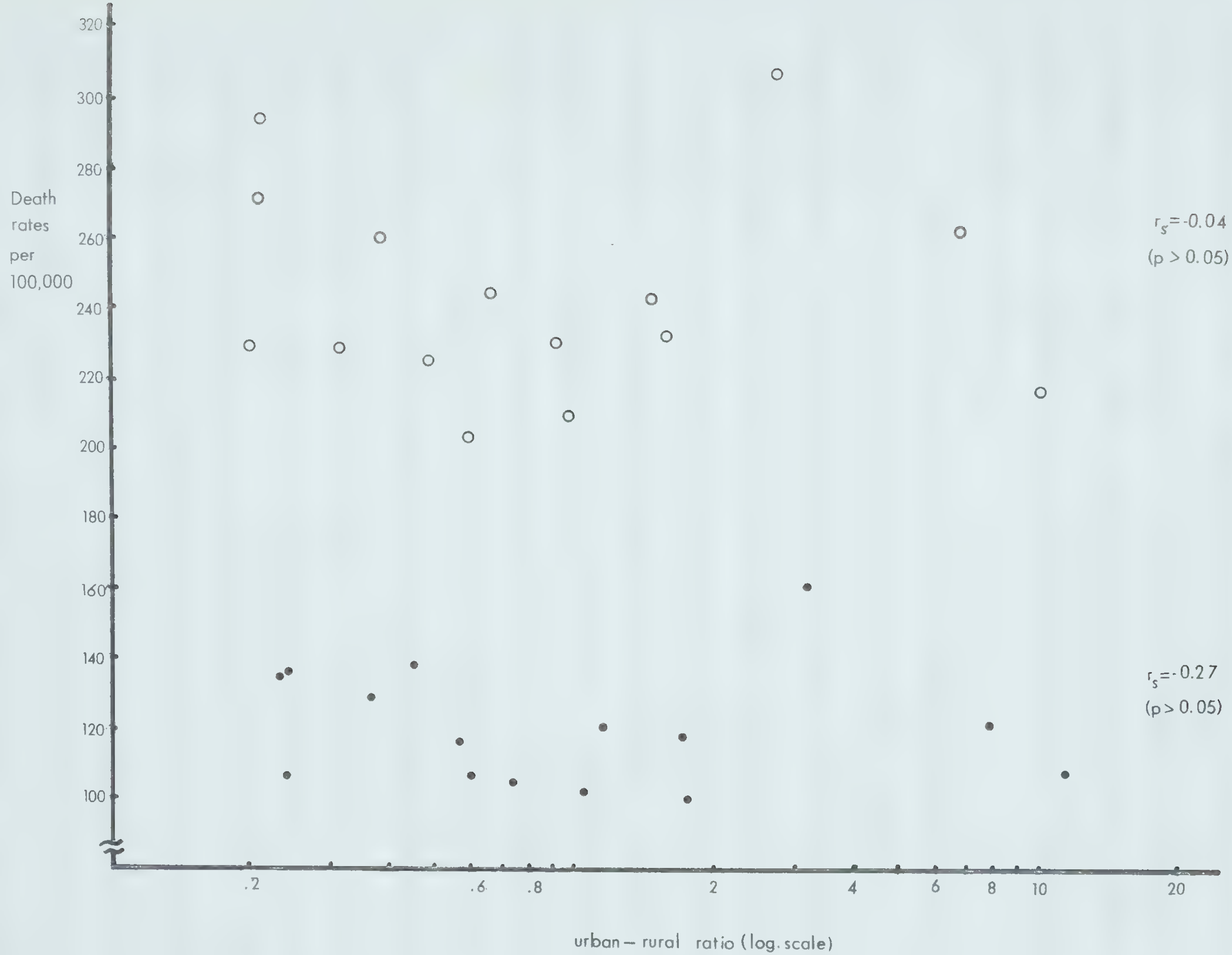


Figure 32 Death rates (A.81) and the Urban-rural ratio (source: Dominion Bureau of Statistics, 1966)
O Males • Females

hospital beds, and of active hospital beds. Values for each type were grouped into categories in ascending order for mapping purposes (table 14). Figure 33 shows that no correlation with death rates for either sex can be expected for these factors since all rates are rather widely, and uniformly scattered. Statistical tests seemed not to be worthwhile.

The last correlation of socio-economic factors with death rates concerned the population density distribution. The data are listed along with the health service facilities data on table 14. These, also, are grouped into categories in ascending order to simplify mapping and to recognize trends more easily. As will be obvious from figure 34, no correlations emerged between mortalities and population densities in the Census Divisions.

For none of the socio-economic factors were statistically significant correlations established with confidence, but most parameters of the physical environmental factors showed associations between their distribution patterns and distribution patterns of death rates A.81. All parameters of weather and climate in the three climatic zones indicate an increase in mortalities from the "short cool summer" zone toward the "grassland" zone. Temperature ranges and Chinook frequencies, both suspected as stress indicators (B. DeRudder, 1952) seem to have no effect on the diversity of the spatial distribution of

Table 14: Death rates (A.81) by Census Divisions for males and females, 1964-68 and Health Service Facilities and population density, 1964

Males

Census Division	Death rate (rounded)	Physicians & Surgeons (category)	Nursing & Auxiliary Hosp.Beds (category)	Active Hospital Beds (category)	Population Density (category)
12	204	2	1	3	1
14	210	2	1	1	2
6	219	5	4	6	5
15	227	1	2	3	1
13	230	2	2	2	2
7	230	3	3	2	3
8	232	4	3	6	4
9	233	3	1	2	2
2	244	5	3	4	4
3	246	3	5	2	3
10	261	3	5	3	3
11	264	5	4	6	5
5	273	1	2	2	3
4	295	3	1	2	2
1	304	4	3	2	2

Females

Census Division	Death rate (rounded)	Physicians & Surgeons (category)	Nursing & Auxiliary Hosp.Beds (category)	Active Hospital Beds (category)	Population Density (category)
9	100	3	1	2	2
8	102	4	3	6	4
3	105	3	5	2	3
12	107	2	1	3	1
6	108	5	4	6	5
13	117	2	2	2	2
15	118	1	2	3	1
2	118	5	3	4	4
14	121	2	1	1	2
11	121	5	4	6	5
7	128	3	3	2	3
5	134	1	2	2	3
4	136	3	1	2	2
10	138	3	5	3	3
1	161	4	3	2	2

category:	p.10,000	p.10,000	number	p.sq.m.
1	0- 4	<10	<100	<1
2	5- 6	10-20	100-299	1- 5
3	7- 8	21-40	300-499	5-10
4	9-11	41-60	500-699	10-15
5	12-16	>60	700-899	>50
6			>900	

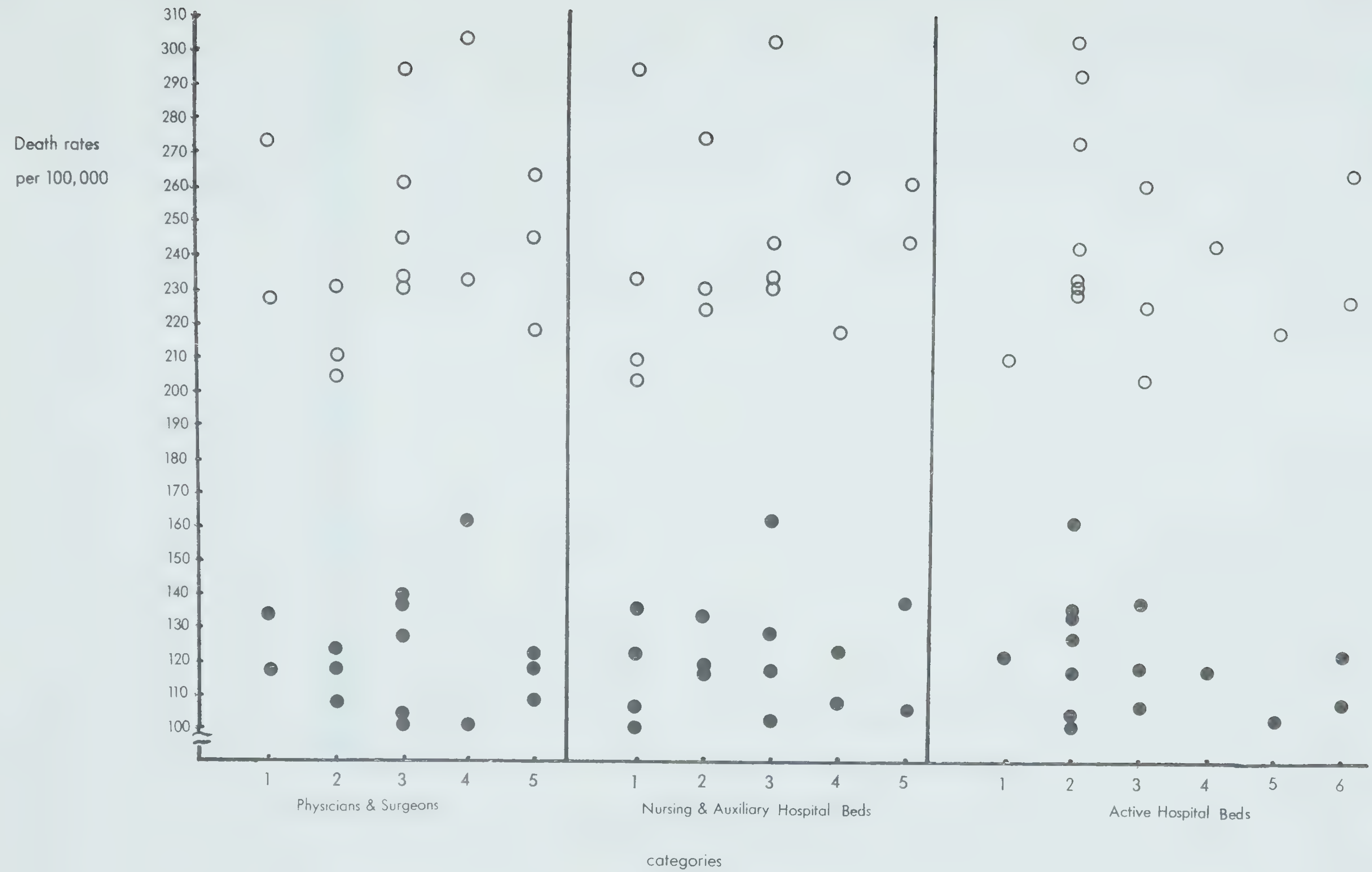


Figure 33 Death rates (A. 81) and Health Service Facilities (source: "Atlas of Alberta", 1969)

O Males ● Females

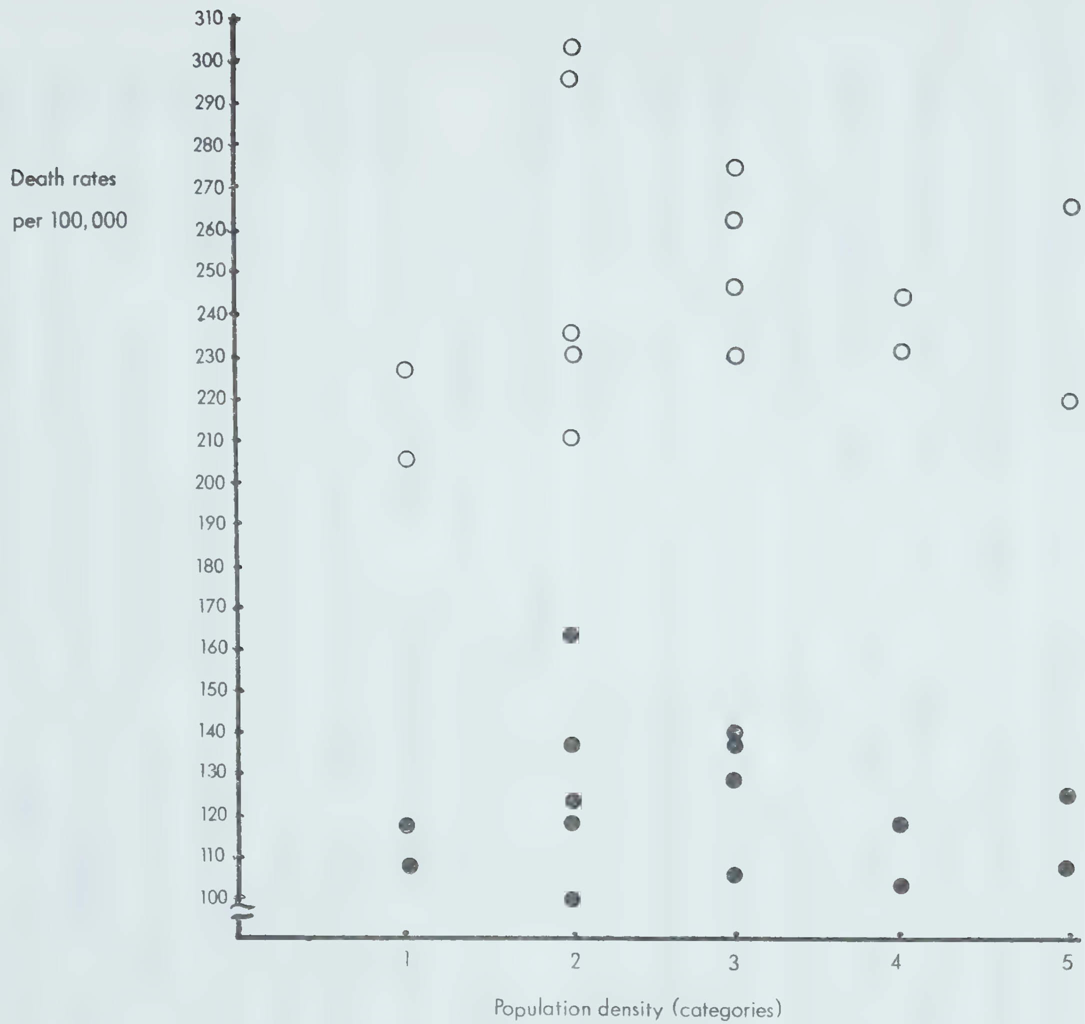


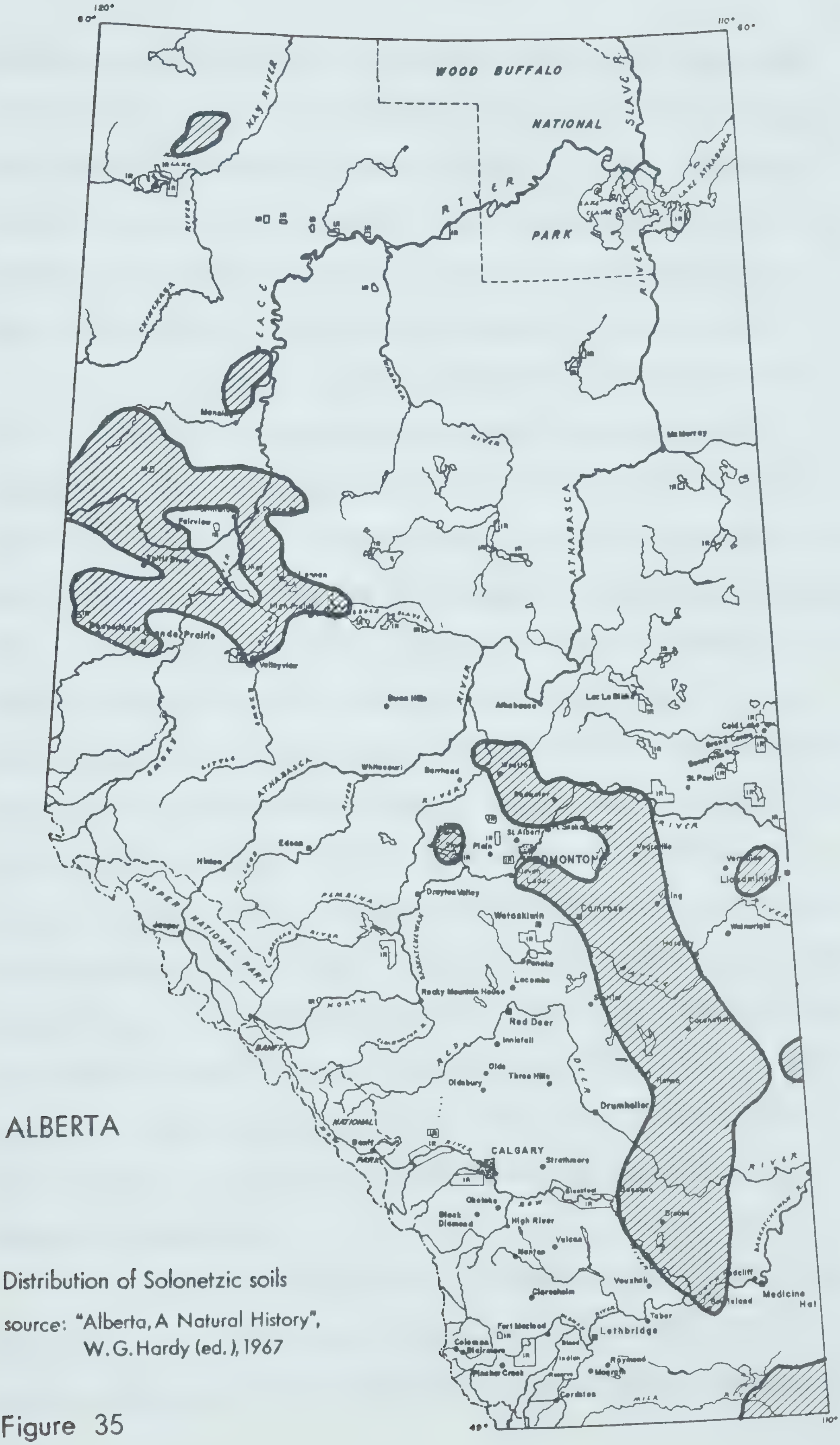
Figure 34 Death rates (A. 81) and Population density (source: 'Atlas of Alberta,' 1969)

O Males ● Females

mortality in Alberta.

The influence of water hardness upon mortalities from A.81 in the eight municipalities could not be established by statistical correlations, although, the mortalities for males are significantly higher in municipalities with very soft potable water, except for Camrose and Medicine Hat (table 12). These two municipalities have a significantly higher death rate for both sexes, but the drinking water supply is relatively hard in Medicine Hat (160 ppm), and in Camrose (237.7 ppm), the hardest among all eight municipalities. The high death incidence of these two municipalities will be considered again later since it is suspected that levels of water hardness may adversely affect people at risk. This adverseness seems to vary according to the dominance of the other hardening elements in the water.

It should be noted that all significantly low mortality rates occur in areas without solonetzic soils, and all with significantly high mortality rates (except one) in areas with solonetzic soils. A relationship between high death rates and solonetzic soils may be assumed. The distribution of solonetzic soils in Alberta (figures 31 and 35) parallels roughly the trend of the Rocky Mountain Ranges and spreads, in a wide band, from northwest to the southeast borders of the province with a major interruption only along the Athabaska



Distribution of Solonetzic soils

source: "Alberta, A Natural History", W. G. Hardy (ed.), 1967

Figure 35

drainage basin. Census Divisions located in this band of soil are seen to have average to significantly higher than average mortality rates (table 13). In contrast, Census Divisions that do not cover solonetzic soils have average to significantly low death rates, except for Census Division 5, which has a high mortality rate.

Solonetzic soils, classified as Halomorphic soils, develop in arid and semi-arid regions under limited or poor drainage conditions. They are characterized by a very high concentration of sodium in association with the soil colloids (H.O. Buckman and N.C. Brady, 1969) and, as sodium carbonate compounds. They are usually highly alkaline, due to sodium carbonate, and feature a dark colored, salty surface produced by upward dispersed humus in capillary water. These characteristics account for the name "black alkali" given to some solonetzic soils. Another type of solonetzic soils, referred to as "white alkali" soil lacks humus; and only the salts are carried upward to the surface by capillary action where they remain when the water evaporates to produce a white residue on the surface. These soils, also, contain a high amount of sodium, besides calcium, magnesium and potassium compounds.

Attention here will be given only to the high quantities of sodium ions in solonetzic soils; these may be transported by run-off or other transportational

processes into streams and rivers where they may, via the drinking water supply, become part of man's diet with apparently detrimental influence over his metabolism. Persons suffering from heart ailments, clinically established or not, will ingest sodium from these potable waters in greater amounts than may be safe.

A low-sodium diet, often referred to as "low-salt" diet, is one of the standard procedures in the treatment of cardiac patients, and usually focuses on the intake restrictions of sodium chloride (table salt) without consideration of sodium ions ingested from other chemical combinations. G.B. Elliott and E.A. Alexander (1961) reported on cardiac patients, treated in the Calgary General Hospital, and discharged to their homes in well improved condition, who suffered renewed heart decompensation for which they had to be readmitted to the hospital. The clinical symptoms and laboratory tests performed on these patients, after readmission, indicated a high sodium intake during their stay at home, although, they had followed strictly their prescribed "low-salt" diets. After short times of treatment in the Calgary hospital the patients improved rapidly. A chemical analysis of the patients' home water supply uncovered the source of sodium as compounds of sulphates etc. not detectable by a salty taste, in the domestic well waters. The hospital's drinking water,

by contrast, was found to contain a very insignificant quantity of sodium. A great portion of three hundred samples of well water in southern Alberta, up to the 52nd parallel, subsequently analyzed, showed high sodium levels of up to 4,200 ppm, and led to a study of the geology and soils of this area. Bedrock of marine origin and solonetzic soils, particularly in the prairie regions, were found to be associated with the high sodium levels of the drinking water from wells and in surface flow.

It seems reasonable, therefore, to assume an association between solonetzic soils and significantly higher death rates for disease A.81 in the whole province. This association could be linked with an above normal intake of sodium into the system by persons at risk to heart disease A.81. The one exception, Census Division 5, mentioned above, with significantly high mortality rates in an area without solonetzic soils may, nevertheless, be possibly related to an abnormal sodium content in the drinking water supply. A great part of this Census Division lies in the South-Saskatchewan drainage basin, which is crossed from west to east by the Bow River (figure 35). Upstream of the Bow River lies Calgary's industrial complex which uses its own practice of softening the very hard water (205.70 ppm) for industrial purposes as the city does not supply this service. W.A. Sodeman and D. Meyer, (1955) studied the effects of

water softening processes, especially those which donate sodium, in use in private homes and in the University of Missouri in Columbia, Missouri. They found that sodium levels, dependent upon the amount and quality of softeners used in the drinking water, can reach levels which may nullify the effect of a "low-salt" diet. If it could be established that water softening methods, practiced by the industries (and home owners) in Calgary contribute sodium at high levels into their effluent waters and the Bow River which traverses Census Division 5, then the hypotheses of the contribution of sodium to a high mortality rate in Census Division 5 may find support if these waters are used for drinking among the population downstream on the Bow River. Relations to solonetzic soils would not apply, or be necessary, but would confirm the high incidence of disease A.81 among residents deriving ingested substances from solonetzic soils.

The correlation of death rates in municipalities with water hardness, discussed above, was found not to be significant statistically for either sex, mainly because the death rates in Camrose and Medicine Hat were too high (<u>figure 30</u>) for the hard water consumed there. If the high sodium level hypothesis proposed can be tested, a possible explanation may lie in the location of Camrose in an area of solonetzic soils (<u>figure 35</u>). Medicine Hat's location on the South-Saskatchewan River downstream from its passage

through solonetzic soils could also be assumed to be the cause of a great amount of sodium in its domestic water supply. If this could be tested and found to be true, it may be that in both municipalities the positive water hardness effect may be cancelled by the high sodium levels in the potable water.

The route of sodium to enter the human body in abnormal doses is not restricted to water transport. A great variety of plants used for consumption by man feature a low to high tolerance to sodium compounds in solonetzic soils. Crops grown on these soils: peas, rape seeds, sugar beets, alfalfa, barley, carrots, lettuce, oats, onions, potatoes, tomatoes, cabbage etc. (many of them garden crops) may, therefore, adsorb a great amount of sodium into their system, although it is of no nutritional value for their growth (H.O. Buckman and N.C. Brady, 1969, p.37). They may, on consumption, contribute to the accumulation of sodium in the human system, and like sodium rich water, nullify the "low-salt" diet effect recommended for persons with identified heart disease. The effect on persons with non-diagnosed heart ailments may, in the absence of a proper diet, be of even more serious consequence.

Soil development is dependent to a great degree upon plant cover; plants and soils are both closely

interrelated with the climate for their types and characteristics. This is true, partly also, for the quality and quantity of surface and ground water which flow in certain climatic regions. It is, therefore, logical, that all discussed physical factors in some way, even if not always provable by statistical tests, may play a role to some extent in the spatial distribution of heart disease A.81.

All socio-economic factors correlated with heart disease A.81 death rates could not be statistically proven. The urban-rural ratio taken as an index showed urban populations greater than rural populations only in five Census Divisions and in ten Census Divisions rural populations greater than urban for 1966. The two metropolitan Census Divisions 6 and 11, with an urban-rural ratio of 9.93 and 6.73 respectively (for males) may be compared for their death rates (figure 4). Both Census Divisions, to a greater extent urban than the thirteen remaining Census Divisions, differ from one another in mortality rates. Census Division 6 has death rates significantly lower than the average and Census Division 11 significantly above. It seems, therefore, that socio-economic life style effects upon the mortality distributions can not be expected, or detected with the help of the available data.

Correlations between death rates and health service facilities could also not be established. The reasons may be, that health services, at least in the southern half of the province are adequate to serve the population, and that services often are given across the Census Division boundaries for people who can exercise preference because of the availability of choices of medical or clinical services. Accurate results from these tests, it is concluded, can not be expected.

The effect of population density upon mortality distributions, also, found no statistically significant association. The highest densities occurred in the two metropolitan Census Divisions 6 and 11 as might be expected. For both a population density of over 50 persons per square mile was obtained, and it was assumed that they differed not considerably from each other. However, the mortality rates differed. The population density in the whole province, ofcourse, is very low in comparison with other countries where correlations might be applicable. Current densities perhaps do not yet impose stress upon people at risk, except possibly in small localized areas such as overcrowded city districts, rooming houses etc.

Of the environmental factors discussed above in relation to the distribution of death rates from heart disease A.81 in Alberta, only the physical ones

of climate, soils and maybe water quality were found to correlate statistically, or to suggest suspicion which deserves further investigation. A summary of all tests for associations of environmental factors with death rate distributions for heart disease A.81 is shown on <u>table 15</u>.

Table 15: Correlation tests; death rates (A.81) with environmental factors by Census Division for males and females

Physical factors	Correlation tests			
	r[1]		r_s[2]	
	Males	Females	Males	Females
Climatic zones	0.786*	0.598*		
Mean annual precipitation(inches)	-0.672*	-0.797		
Mean annual number of days with precipitation	-0.703*	-0.572*		
Mean annual snow fall(inches)	-0.632*	-0.654*		
Sunshine hours p.y.	0.663*	0.521*		
Chinook frequency (days p.y.)			0.311	-0.168
Mean annual temperature ranges (^{o}F)			-0.090	0.400
Water hardness	-0.002	0.379	-0.008	0.203
Solonetzic soils	assumed to be significant, no tests performed			

Socio-economic factors	Scatter - diagrams
Urban-rural ratio	no association
Health service facilities:	
physicians & surgeons	" "
nursing and auxil.hosp.beds	" "
active hospital beds	" "
Population density	" "

[1] correlation coefficient

[2] Spearman's coefficient

* $p<0.05$

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

It was suspected from the outset that the spatial distribution of mortality from arteriosclerotic and degenerative heart disease in Alberta might be scattered; that the mortality should differ considerably among Census Divisions and the Municipalities, similar to observations made in other countries was also presumed. Striking, however, are the geographical locations with the highest and the lowest death occurrences. A spatial trend of increase in mortality from approximately west to east in the southern half of the province was established to be persistent over time.

Since the "problem" areas with significantly high mortality cluster in the south-eastern half of the province it seemed reasonable to conclude that stronger environmental stress influences exist there upon people at risk to die from heart disease. The physical and socio-economic factors of the environment, selected for their applicability and data availability were analyzed for possible associations with this disease. Possible influences of socio-economic factors could not be confirmed, but the physical factors indicated powers of direct and indirect stressors present in the environment. These

deserve attention.

Although the small number of physical and socio-economic factors taken into account, and the generalization of both mortality and environmental data allow only very general conclusions, valuable clues for tentative explanations of mortality diversity in the province seem to have been found. Water, dependent upon weather, climate and soil for most of its characteristics, should be seriously considered as a stressor upon the population at risk to die from heart disease. Solonetzic soils may be regarded as potential hazards to persons with diagnosed and undiagnosed cardiac conditions. This is because these soils constitute sources of high quantities of sodium ions. Sodium, often as tasteless chemical compounds, can be transported, via water and crops associated with the solonetzic soils, into man's diet, and seems to have detrimental effects upon human metabolism. The corrective "low-salt" diet of persons with diagnosed heart conditions (The Merck Manual, 1972) may apparently be nullified by the unrecognized intake of high levels of sodium. The danger of heart decompensation for people not aware of ailment from heart disease and, therefore, without the benefit of a "low-salt" diet habit, may be multiplied by the addition of high quantities of sodium to their systems.

High mortality from arteriosclerotic and degenerative heart disease in the south-eastern half of Alberta may be explainable, in part at least, by the geographical distribution of sodium rich, solonetzic soils. Distribution of low mortality coincides with an absence of solonetzic soils mostly in areas west of the wide band of these soils. Weather and climate can be considered as instrumental in the development of solonetzic soils and can not reasonably be associated directly with the spatial diversity of A.81 mortality in the province.

An association of soft potable water and high mortality from heart disease may be possible in spite of the negative statistical results obtained, if the hypothesis of the sodium hazard present in the drinking water could be tested for the municipalities concerned. Water analyses of the water supply in Camrose and Medicine Hat may add to a better understanding of the assumed relationship between high mortality, soft water, and the sodium level in the water. If high levels of sodium in the drinking water of the two municipalities are found, it will be reasonable to assume a relationship between the sodium content and the high mortality which could cancel the otherwise positive effect of hard water on mortality occurrences. In order to clarify any possible influence of soft water upon higher mortality, the water

supply in all eight municipalities should be investigated again, and data on water sources and sodium content collected. It must be kept in mind, however, that other water constituents may play a role in providing stress upon the metabolism of people at risk (H.V. Warren, 1972).

Consideration must also be given to the addition of quantities of sodium to the drinking water supply by water softening processes applied in hard water areas. This addition may cancel the supposedly beneficial effect of hard water and multiply the detrimental effect particularly for persons at risk and suffering from undiscovered heart ailments. Investigations of drinking water sources and the sodium content thereof consumed in Census Division 5 may shed light upon the high mortality experiences there. If a great portion of the population should consume Bow River water, and high levels of sodium can be identified in it, one may assume that water softening processes used by industries and home owners in Calgary, upstream from Census Division 5, may donate the greatest part of these quantities to the river with their softened effluent waters. Although, Census Division 5 does not lie in the band of solonetzic soils, a sodium donation could contribute to the high mortality distributed there. On the other hand, should well water be consumed by the greater part of the population, it would be worthwhile to study the geological strata from which it is extracted. Many wells in this area

may recover water from underlying geological formations of marine origin having high sodium content (G.B. Elliott and E.A. Alexander, 1961). Therefore, two possibilties of sodium accumulation in the water supply may have to be considered for Census Division 5.

Another important aspect is the contribution of sodium to crops grown on solonetzic soils. Little attention is usually given by biochemists and nutritionists to the sodium content in plants since it is of no known nutritional value. But because it may be assumed that garden crops, particularly in rural areas are a considerable part of the diet of the local people, analyses of sodium content in crops would be of great interest. It would make clearer not only the possibility of the sodium hazard hypothesis but also support the proposed relationship of solonetzic soil distribution with the distribution of the high mortality incidences in southeastern Alberta.

It is proposed, therefore, that further research to explain the diversity of mortality distributions in the province should focus on the sodium levels in the drinking water and garden produce from areas with high mortality by comparison with those from areas of low mortality occurrences.

T.W. Anderson and W.H. LeRiche, 1970 suspect the seasonal fluctuation of heart disease mortality to be related to the seasonal fluctuation of serious

respiratory diseases of infectious type. It would be of interest to consider this aspect and to enlarge upon it by investigation of seasonal allergenic respiratory diseases. These may be of importance too in the grassland region of southeast Alberta where particular plants, e.g. members of the sage family produce aero-allergens like spores, pollen etc. These may lead to allergies and additional stress in persons suffering from heart disease.

Furthermore, investigation of mortality distribution patterns associated with the mentioned factors in the bordering areas of Saskatchewan and Montana using identical research methods, would be informative as regards any continuation there of the patterns and trends observed in Alberta.

Emphasis on physical factors of the environment emerging in this study does not imply that socio-economic factors are to be neglected in further research as they too have significant importance. However, it is believed that a continuation of research into physical factors of the environment may lead to insights which could clarify the importance of sodium as a contributory agent. Such a procedure may help to explain the mortality distributions in Alberta, and its results could subsequently be utilized in further medical research, and in planning preventive measures to be taken in the struggle against a primary "killer" in Alberta and in other parts of the world.

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